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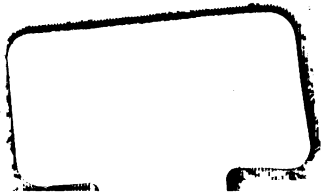

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PRACTICAL

INTESTINAL SURGERY

— BY —

FRED. B[illegible] ROBINSON, B. S., M. D.,

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VOL. I.

"*A word fitly spoken is like apples of gold in pictures of silver.*"—Solomon.

1891.
GEORGE S. DAVIS,
DETROIT, MICH.

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This book is dedicated to

DR. NICHOLAS SENN,

OF MILWAUKEE, WISCONSIN, TO WHOSE ORIGINAL GENIUS AND UNTIRING ENERGY INTESTINAL SURGERY OWES MUCH OF ITS MODERN PROGRESS, BY

THE AUTHOR.

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PREFACE.

The past six years I have devoted study and practice to gynæcology. The loss of a woman in abdominal section through intestinal perforation induced me to study, experimentally, how to avoid and repair such dangers. As the abdomen is the recognized field of the gynæcologist. I followed this experimental work with care and pleasure for three years, embracing about 200 operations. I thoroughly believe in specialists for the advancement of medicine, for new ideas; and that each man should practically cultivate from Nature his chosen department, as men do things well only when they do them automatically. This book is the result of original experimental work, and an attempt to add something to the field of gynæcology. Any gynæcologist who opens the abdomen for some preconceived view, should be able to skillfully treat any unexpected contingency. Intestinal surgery has been completely revolutionized the past three years, and its progress during that time has had no parallel in history. Much of the field is yet open and unsettled, but gradually many of its new operations are being recognized as established surgical procedures, from simple success. The greatest improvement was intestinal anastomasis, by the aid of perforated plates, introduced by Drs. Senn and Connell. The department is at present in the most rapid state of progress. The rising of a great hope is like the rising of a sun, and it is with pleasure akin to this that I present to the Profession some of the new improvements, as the Segmented Rubber and Raw-hide Plates, and the new Invagination Operation, of the author. Also the author's modification of Jobert's operation by omitting invagination sutures. Besides the above four original points, I present in this little volume new views and dangers relative

to invagination, and suggestions to avoid them by definite intestinal *technique*. It is also hoped that this book will stimulate the young physician to do orignal work. Nature's laws are always fresh and new, and yet contain untold treasures which will yield to the servants of Labor alone. I am indebted to all workers on the intestines, but especially to Dr. Senn of Milwaukee, Dr. Treves of London, and Dr. Leichtenstern of Tübingen. I wish to thank Dr. D. D. Bishop, and the lawyers, Messrs. Vaughan & Copeland of Grand Rapids, Wisconsin, for valuable service in the experiments. Since removing to this city, Dr. Arne Zetlitz has assisted in the work. Drs. C. S. Miller, W. J. Gillette and W. V. Anderson have also assisted and shared in the operations. Drs. Miller and Gillette did some of the recorded experiments. Drs. Thorne, Woods, Brayton, Havighorst, and others were present at some of the operations. Eight of the designs I suggested to Dr. J. W. Lilly, whose execution speaks for itself. The remainder were drawn by myself. I have not aimed at literary excellence, but have attempted to be as clear and explicit as possible, and to *truthfully* record the work—even the worst and most fatal forms. The best surgery is built on its faults. The appearance of the pronoun "I" is not intended as egoism, though it may individualize the work. I am fully conscious of repetitions in the book, but part of that is due to the experiments being done in sections and at different periods, and part is due to intentional repetitions of essentials.

Toledo, Ohio, September, 1890.

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CHAPTER I.

THE ALIMENTARY CANAL.

The primitive alimentary canal consists of a straight tube beginning at the mouth and ending at the anus. It is hung to the underside of the vertebral column by a fold of peritoneum. The digestive tract of man is this same tube simply modified by evolution through ages of environments and food, by inscrutible increments. At first we can see no difference in the size of the tube, no stomach, no small intestine and no large one. In process of time the embryo shows a little dilatation at the front end of the tube, which becomes the stomach and is supplied by the gastric artery. More time and a greater blood supply by the superior mesenteric artery, encourages a loop of intestine between the stomach and the descending colon to grow rapidly in length, and at the middle of this loop a little bulge occurs, which shows the rising cœcum and the beginning of the large intestine. The remaining tube, to the rectum, is supplied by the inferior mesenteric artery. Thus, then, are three parts of the alimentary canal supplied by three distinct arteries—gastric, superior and inferior mesenteric. The blood supply has much to do with the determination of the size and rapidity of the visceral growth. The stomach and descending colon

retain their primitive position, held by the peritoneum, but that part of the tract supplied by the superior mesenteric artery, grows rapidly in length and size, and twists upon itself until the cœcum gains its final home in the right iliac fossæ. It can be learned from this, that all the peritoneal attachments are acquired, except that on the stomach and descending colon.

The vertebral digestive tract contains four distinct layers, with distinct functions of interest to the surgeon. The first is the mucous membrane. It arises from the hypoblast of the embryo. All the appendaged glands arise from the epithelium of this membrane. These glands are salivary, mucous, thymus, thyroid, lungs, liver, pancreas, and gastro-intestinal. All these organs, though very different in their ultimate function and structure, arise from the epithelium of the mucous membrane of the digestive tract.

The second layer is the submucous, or connective tissue layer, which serves chiefly as framework to support and conduct the blood- and lymph-vessels. The third layer consists simply of a circular and longitudinal muscular layer. The function of this layer is contractility, producing what is called peristalsis. The fourth layer of this alimentary tract is a serous coat, a lymph sac. This lymphatic membrane has a parietal layer covering the walls, and a visceral layer covering the viscera of the abdominal cavity. This coat, or the peritoneum, is the one of prime importance in intestinal surgery. Proper knowl-

edge and respect for the peritoneum, is the key to all success in abdominal and intestinal work.

THE LENGTH OF THE INTESTINES.

Dr. Treves examined one hundred fresh bodies, and found the average length of man's small intestine to be 22½ feet, and woman's 23½ feet; also the average length of man's colon 4⅔ feet, and woman's 4½ feet; and that the length of the bowel is independent of age, weight, and height, in the adult. Comparative anatomy shows that the horse's intestines are about 12 times the length of his body, an ox 22, sheep 27, goat 27, pig 17, dog 5, cat 5, and man 4½.

The small intestines of mammals are about 4 times as long as the large. Dr. Treves notes in his measurements, that when born, the baby's small intestine is 9 feet 5 inches, and the large intestine 1 foot 10 inches. It is observed that a baby's small intestine will grow 4 feet in two months after birth, and that the colon does not grow any the first four months. The length of the intestine of each species of animal depends on physiological processes accompanied by quantity and quality of food, and the time of life in which it is assimilated. The small intestine is the business part of the digestive tract; it is the active portion of the nutritive laboratory; therefore its growth depends on the nature of the food it assimilates and receives. It is a vascular emporium, highly supplied with blood, lymph, and nerves. Nutritive

food, in the natural period of growth, alone determines its size. The amount of fresh blood traversing the alimentary walls, and the size of the nervous supply, decides its limits of growth.

The colon grows slowly, owing to its passive physiology, and its small and inactive blood, nerve, and food, supply. The colon is simply a passive fæcal receptacle, to be periodically emptied when too full. It is a dilated sac, with a sphincter at each end. It becomes sacculated before birth, and the muscular bands are about one-half as long as the colon.

The primary weak points in man's intestines are, the pylorus, the cœcum, and the rectum. The secondary weak points are, the bends and angles of the large intestine, the hepatic and splenic curves in the colon, and the sigmoid flexure. Man's intestine has three sphincters—the pyloric, cœcal, and rectal—which might be called three ani. The object of these sphincters is to retard and retain the fæcal circulation. The nerve and blood supply of the alimentary tract is mainly sympathetic, but the cranial and the spinal also play a rôle. The solar, hypogastric, Auerbach's and Meissner's plexus, preside over the intestines. A thorough anatomical knowledge of the alimentary canal is indispensable to any abdominal or intestinal work. Such practical information as is required in this highly responsible field, can only be secured by faithful study of the bodies of man and animals. The slaughter-house and the butcher-shop

are free in every locality, and equally full of practical information. I think all future intestinal surgery must be based on animal experimentation, on faithful, original, continued research.

The strong muscular knots in the alimentary tract, though weak from the standpoint of disease, are subject to dilatation and contraction periodically. Their vascular supply is thus fluctuating, and subject to a maximum and minimum blood supply. At such points, disease is apt to arise, just as it does in the changeable genital organs and breasts of woman. Considerable muscular rings are found heaped together at the pylorus, cœcum, and anus. In such periodically active tissue, cancer delights to ensconce its wandering cells. The pylorus may be viewed as man's first physiological anus, the ileo-colic valve as his second, and the end of the rectum as his third but mechanical anus.

Applying every method and technique to a rigid test, must be the only excuse for a man to enter the field of abdominal surgery, and especially that of the intestines. Heretofore, intestinal operations have been accompanied by appalling mortality; but such was mainly due to late diagnosis and faulty technique. It is but a short time since intestinal operations were not only severely condemned by the laity, but by influential surgeons, as unjustifiable. But since men have discovered that early diagnosis and improved technique produces successful intestinal oper-

ations, prejudice yields to progress, which has been phenomenal in this field. The old method of procrastinating to operate on an ovarian tumor until the powers of the patient were exhausted, was similar in its high death roll.

Now-a-days, women are advised to have an ovarian tumor removed as soon as diagnosed, and so it has come to the point of perfection when men can remove 100 ovarian tumors without a death. Though, from natural functions of the intestines, operations on them are more liable to be fatal, yet progress in this field has been, and will be, remarkable, because experimental research on animals is the head and front thereof, and the rock and base already laid, in fact, for future use. The importance of obstruction of the intestines becomes more significant when it is considered that about 5,000 persons die annually in the United States from this cause, exclusive of hernia. Toledo with 83,000 people, loses some 8 persons every year from intestinal obstruction.

CHAPTER II.

THE PERITONEUM.

The primitive peritoneum of all higher animals, including man, consists of a single fold of membrane extending from the spine to the single straight alimentary canal. The peritoneum is attached along the middle line of the body just under the vertebral column, and the primitive fold serves as a bed for the single straight gut, as does a hammock for a person. It will be observed from these remarks, that the original peritoneal attachment is all in the middle line of the body. It may also be noticed that any other peritoneal (but the middle) attachment is acquired. The only primitive attachment of the peritoneum left in man in the median line is, the descending colon and about half the transverse colon. All other anchorage, supports or attachments are acquired. In short, the inferior mesenteric artery supplies half of the transverse colon, and all the descending colon to the rectum, and constitutes all the remaining primitive peritoneal attachments of man. The acquired peritoneal attachments are the mesentery, the ascending- and half the transverse-meso-colon. The future growth of the peritoneum takes place between the pylorus and the middle of the transverse colon, where the gut evolves into a loop. The space between the transverse colon and the duodenum forms the neck of the large grow-

ing intestinal loop which is supplied by the superior mesenteric artery. At first the large and small intestines appear alike, but soon, in this great loop, at about its middle, an enlargement occurs which finally develops into the cœcum and its appendix. This loop, which is supplied by the superior mesenteric artery, in process of time is gradually withdrawn into the abdominal cavity, through the umbilicus where a part existed. Then a rotation occurs on its axis. The rotation continues until the cœcum reaches its final resting place in the right iliac fossa. The rotation of the large intestinal loop is due, no doubt, to the unequal dragging and growth of the two bowel loops supplied by the superior and inferior mesenteric arteries. The small intestine grows rapidly, being supplied by a large artery, and a majority of the monstrous solar plexus, consequently the two elements which cause nutrition—blood and nerve supply—being liberal, assimilation is rapid and extensive.

The large intestine grows very slow, being supplied by a small artery and small nerve plexus. It is a passive fæcal receptacle, and periodically emptied when over-distended. The supply of nerves, blood, and nutrition, is accountable for the unequal growth of the peritoneum as well as the loops of the intestines.

At first the cœcum will be found near the umbilicus. It will gradually ascend and pass toward the right, in front of the duodenum, under the liver, over

the right kidney, and sink with time into the right iliac fossa. I have found the cœcum in puppies at the end of the transverse colon; it had not yet descended, nor formed scarcely any descending colon. Man's duodenum has lost all its mesentery, and peritoneum exists only on its front surface. This arose in the evolution of ages from the unequal visceral growth and dragging of organs. The change is well seen if one dissects animals that habitually stand on four feet; through those who stand partly on four and partly on two, and finally those that habitually stand on two feet, as the higher apes and man. Dogs have a long meso-duodenum, but by evolution this was gradually lost through the monkey and ape, until we come to man, whom we find has none.

A curious fact may be noted, that the peritoneum is more liberal and extensive among all animals below man, and that the latter sports the least of that great lymph sac in proportion to his size. The peritoneum gradually lessens from the herbivora, through the carnivora, quadrumina, and is least in bimana's so-called highest point—man. This is accounted for by food and ages of environments. Man's intestines are about the shortest, for the length of his body, of all animals. The coarse, raw, scarcely soluble, non-diffusible and innutritious food eaten by animals, needs a large and extensive laboratory, made up of wide expansive walls of peritoneum and washed by long and large blood-streams, to feed the hungry tis-

sues; while man, with his cooked, digestible food, requires a short gut, and less peritoneum to support the fewer blood vessels, which easily flood away the soluble nutrition. Thus food and environment, by the evolution of ages, change and obliterate animal organism. Evolution, in the case of the peritoneum, improves and betters man by cutting off the dangers of disease. It simplifies matters by lessening the surface of the peritoneum, by shortening the gut and diminishing the number of arteries, and by curtailing an organ exposed to disease and trauma. When man got on his hind part, he improved his utility and dexterity. He lessened the size of his inferior mandible, and no doubt swings a smaller under jaw. His voice, with his hand free, gave him a chance to develop mentally to much better advantage. No doubt the two great elements which developed man,—speech and hand—combined with the fact that as time progressed man began to live by his wits, insured rapid and extensive mental growth. By standing on his feet, man gained more rapidly by the more advantageous use of hand, speech and mentality. In short, when man got on his hind feet, his field of mental growth was immeasurably enlarged; and standing on a previously unknown eminence, with his wits developing his cerebrum, all assured him that he was elected to be the great animal of the earth for all time.

All this was favorable to the development of the unseen forces of man. But when man raised to the

upright position and walked, and remained continually on his hind limbs, he injured himself physically. He entailed on the peritoneum, and on his physique, a thousand woes. He mainly injured his circulation. The heart had now to bear a previously unknown burden. This taxed his system and brought disease upon him. The upright position induces hernia by putting a strain on the weak points of the wall of the abdominal cavity. The present position of man's viscera tax circulation more severely than in four-footed animals.

Hæmorrhoids are almost the sole property of man, and varicocele is generally his peculiar inheritance. Floating kidney and spleen show the weakness of the upright posture, and the tax upon the heart to drive the circulating fluid through such pendulous organs. The extended pathology of all man's pelvic organs are sufficient proof that his perpendicular condition witnesses against him. Animals are quite free from almost all of the above diseases.

Observe the poor vertical uterus around which woman is built, standing, doubtfully, capering on its giddy end, with its heavy responsibility balanced upward. Notice how it careers through a variety of naughty courses, of floods and droughts. Study the arrogant and defiant positions it assumes on account of man getting on his feet. Flexions, versions, and prolapses, are the natural physical rewards of the upright posture. Difficult and dangerous births come

from narrowed pelvic bones caused by the weight of the trunk being supported in a new position; the wide box-shaped pelves of other animals become a narrow cone in man.

Civilization increases the relative size of the head, though the bony pelvic outlet proportionally decreases by insensible increments due to bodily posture. Really, woman seems defective in structural composition, and incomplete in her evolutionary development.

The long perpendicular blood-column places upon the heart an excessive tax to overcome the force of gravity. Hence, though man gained vastly in mental development by an upright posture, he deteriorated in his physique. Future eras may correlate structure and posture into ultimate utility.

THE MESENTERY is longer and more extensive in animals than man. It extends in man from the end of the duodenum to the ileo-colic valve, running from the second lumbar vertebra to the right sacro-iliac symphysis, being about six inches long. The length of the mesentery from the spinal column to the intestine, varies in its different parts. The measurements which I collected from the dissecting room, averaged 6½ inches; the extremes were 2½ and 9¾ inches. The longest mesentery was the second, five feet from the duodenum. Dr. Treves gives the result of his measurements as an average length of mesentery to between 8 and 9 inches. Gray says the mesentery

averages 4 inches long. These are quite different figures, but all taken from Nature. I have never witnessed an average length of mesentery so long as Dr. Treves' result (9 inches), nor an average length so short as Gray's (5 inches), except in single cases. The three reports ($4 + 9\frac{1}{2} + 6\frac{1}{2} = 20 \div 3 = 6\frac{1}{3}$) would give the length of an average mesentery to be $6\frac{1}{3}$ inches long, which is not far from Nature. However, I examined one female cadaver where I could draw loops of intestines through *all* the hernial orifices; the coils of both large and small bowel could be drawn several inches beyond the places liable to hernia; the sigmoid flexure, a bend of the transverse colon, would extend two inches beyond the inguinal and femoral rings. This was the most elongate mesentery I ever met. She was liable, during life, to hernia at any moment, and volvulus could easily arise in both small and large bowel from elongated mesentery and loss of fat, giving physical conditions to twist. It may be remarked that if a fresh dead body is opened, the mesentery will not allow coils of intestines to be drawn through the hernial orifices; the loops of bowel will not come closer to the inguinal and femoral rings than the space of one to two inches; so that a normal man in normal condition cannot have hernia. The dog's mesentery is relatively much longer than man's.

THE MESO-COLON played a large rôle in old intestinal surgery, but now loses its importance since

the recognition of anastomosis as a legitimate procedure, and the impunity with which the peritoneal cavity is entered.

The mesentery does not cover the bowel completely. It leaves about ⅛ of an inch of small intestine, and 1 inch of large intestine uncovered by peritoneum. This space is generally filled with fat. It should be borne in mind that the arteries run toward the mesentery, and the veins run away from it.

The left descending meso-colon is the primitive, fœtal, persistent peritoneal fold, and can be found, according to Dr. Treves, in 36 per cent. of cases, while the right ascending meso-colon is found in 26 per cent. This was the result of the examination of 100 fresh cadavers, and is very significant in lumbar colotomy. The idea of entering the descending colon without penetrating the peritoneal sac arose with Amussat. It is, however, apparent to me from work done on the cadaver in the dissecting room, that the reports of surgeons entering the colon without, at the same time, entering the peritoneum, is misleading. I believe in most cases of lumbar colotomy that the surgeon enters the peritoneum, knowingly or unknowingly.

Littres' operation, is colotomy by making an artificial opening in the left groin to drain the fæces from the colon. It may be remarked that it is dangerous to perform any operation on gut not supplied by peritoneum, as gangrene will often follow. The ascend-

ing meso-colon is wholly acquired, and therefore is often absent, according to Dr. Treves, in the ratio of 75 per cent. There is often none in dogs. It is well to remember, in performing right lumbar colotomy. that an ascending meso-colon is present in 25 per cent. of cases.

The peritoneum is a closed sac, except in the cases of females. In the female the endothelium extends from uterine to abdominal end of the Fallopian tube, and shades off into natural peritoneal endothelium on one end, and uterine epithelium on the other. The valvular arrangement of the abdominal end of the Fallopian tube, allows no escape of fluid from abdominal cavity to uterus at other times than menstruation. In ascites, fluid does not pass the tubes. The functions of the peritoneum are significantly far reaching, and the utility of accurate clinical, physiological, and anatomical, knowledge of this greatest known lymph sac, is just beginning to dawn on medical men like a rising sun. It is the result of experimental and practical abdominal surgery. The peritoneum was previously a sacred cavity, the holy of holies, into which the surgeon hardly went once a year and came out alive with his patient. But now neither peritoneum or other serous cavity is free from the knife.

The peritoneum is a monstrous lymphatic; it is the most extensive serous surface in the body. It acts as a moderator between its serous surface and the

blood vessels; it filters out the poisons just like the lymphatic glands; and rejects material unfit for the blood stream. It is lined by polygonal endothelial cells, and fluids pass through in two ways. The most extensive method is when the fluid penetrates the cement like substance between the edges of the endothelial cells; another recess by which the fluid passes the membrane is by the stomata, which are little mouths lined by germinating endothelial cells opening into lymphatics of the peritoneal membrane. Experiments prove that when water is poured into the abdominal cavity of dog or man, and the cavity closed, the water will be passed through the kidneys within the next few days. The peritoneum protects the intestines against injury by friction, as its moistened surfaces glide freely over each other. The peritoneum is a great protector against the diffusion of pus over the viscera, as it will immediately encapsulate the first drop that enters the peritoneal cavity. It will build a barrier round a foreign body in a few hours. This barrier is composed of impenetrable plastic exudation, and holds the foreign body securely imprisoned. Thus may it remain for an indefinite time. The peritoneum holds a peculiar equilibrium of moisture between its endothelia and the blood. Though the peritoneum is such a great protector, nourisher, and supporter of the intestinal walls during health, yet it is in its disturbed functions very suscep-

tible to infection, and prone to allow its extension, and very tenacious in retaining injuries from inflammatory action for successive years. It will brook no uncleanliness, and its subsequent adhesions will stand as witnesses against the tyro in surgery who operates with the sin of infection on his hands. Dozens of experiments have demonstrated that the female peritoneum is more tolerant to manipulations than the male, and I have noted that female cadavers which have borne children during life have a thicker peritoneum than males.

CHAPTER III.

PERITONITIS.

Inflammation of the peritoneum was the cause of death in almost every dog used in my experiments and study, that died; the few exceptions were, generally, shock and marasmus. I do not think that a single dog recovered from general peritonitis. General peritonitis is almost always fatal. The autopsies showed that a very large number suffered from more or less local peritonitis as was shown by remaining adhesions. In the earlier operations, most of the dogs died from peritonitis, for I did not know how to practice cleanliness; but following improvement in technique of operation, in manual dexterity and aseptic precautions, most all the dogs recovered.—Shaving the belly proved the most favorable step in clean work. The peritonitis would assume the distinct conditions of acute and chronic forms. The acute form generally ran its course in a week or less, but the chronic would often last for weeks without visible cause. An autopsy of a chronic form would show the most wondrous picture of dilated blood vessels, coursing in meandering lines of carmine red over extensive fields and bordered by lighter spaces. It was of interest to observe the cause of inflammation persist for weeks, to see square feet of peritoneum studded thickly over with dilated

blood vessels winding through the membrane parallel to each other, like a cork-screw in their tortuous course. The blood vessels were so numerous and so large that much of the dog's blood dwelt in his peritoneum. Such a chronic form often killed the dog. Some dogs recovered with intestines all glued into a bunch, just as I have seen during *post mortems* on the human, where it required an hour or more to unravel the ball of intestines which had resulted from years of repeated attacks of inflammation.

The dreaded enemies of abdominal exploration are peritonitis and vomiting. Tympanitis sometimes arose to a considerable degree, but nothing comparable to what I have observed in man. Under the operation, the dogs' stools generally became liquid, and this enabled gas and fæces to pass off more freely. Vomiting in dogs never rose to that prominence nor distress which I have encountered in man; this may be accounted for by the law that, when a dog is sick he refuses all kinds of food, and sometimes takes no water. Sometimes a week would thus pass, so that the alimentary canal had no burden but the excretal waste of tissue. One prominent feature in peritonitis among dogs, can be truthfully and beneficially transferred to medical practice: It is the paralysis that peritonitis causes among the intestines. The pressure of the inflammatory exudate on the nerve periphery of the peritoneum in Meissner's and Auerbach's plexus which lies in the gut wall, is a dan-

gerous symptom. The autopsy of such a dog reveals partial or general peritonitis with the intestines filled with gas, but only liquid stools. The gut wall has lost its contractility, and peristalsis will be found to have been almost arrested. On performing an operation for a supposed mechanical obstruction, one finds only distended coils of paretic intestines. Mechanical or chemical irritation begets but little response. Such dogs do not seem to suffer as much as in milder cases, owing to loss of receptive sensation in the periphery of the abdominal nervous system, and also from non-intestinal movement. The dogs received no treatment of any kind before or after the operation, but the use of salines in the beginning of peritonitis is sanctioned by nearly all abdominal surgeons as the best known form of treatment; it brings about peristaltic contraction, it makes the gut wall less permeable to pathogenie microbes, it depletes over-distended blood and lymph vessels, and enhances tissue contractility, enabling it to expel its fluid excess and drain morbid material through the rectum.

Paralysis of intestinal action from peritonitis was a frequent and dangerous complication in the experiments. The contents of the bowels would undergo decomposition, developing gases up to all degrees of tympanitis, but not so severe as I have seen in man. It is very difficult to diagnose tympanitis from paralysis of gut wall, and tympanitis from mechanical obstruction. Both may show similar symptoms. The

paralysis may be direct from injury in the operation. It may be indirect as from any local irritation. I observed this form of paralysis in some dogs in their inability to urinate or defæcate for considerable time after the operation. In many dogs difficulties arose for days in emptying bladder and bowels. In others a semi-errect penis would continually exist from one to ten days. Here also the stitches in the belly-wall, as well as the gut wound, enhanced the paralysis from indirect irritation.

This paralysis of intestinal contraction, from indirect irritation, was observed in many ways. A boil on the belly, a crushed or incarcerated testicle, rectal or bladder operation, have been known to cause it. Inflammation of the meningies and the nerve tissue will cause paresis. In some of the worst cases of peritonitis, we tried washing out the abdominal cavity with hot water; marked benefit followed, as the dogs were relieved from shock and very much improved. I think such treatment will be more employed in the future.

Peritonitis brought about all kinds of kinking, flexion, loops, and twisting, but I never saw any obstruction produced by such measures. However, if the tip of the loop is caught by adhesion, it would hinder peristaltic action, as in Littre's hernia, where a portion of the circumference of the bowels is nipped. Care should be taken not to wound a mesenteric gland, as I saw one dog's intestine closed to

almost one-third its lumen a few weeks after the operation, from such a gland being wounded at the time. If one will open a dog during general peritonitis, it can be observed that the distended paretic, venous, congested, loops of intestines, are comparatively still, due no doubt to the pressure of the exudate, or the morbid action of the pathogenic microbes on the periphery of the nerves.

Now, if hot water is poured into the abdominal cavity by the gallon, the intestines will begin to assume more peristaltic contraction, the dog is aroused and stimulated from his stupid lethargy, he brightens, and will soon get up and walk; I used water just as hot as I could bear the hand in. The dogs generally had a rectal temperature from 101 to 104, but when the infection overwhelmed the system, when the toxic substance in the blood was so great that oxidation of impaired tissue was not enough to bring the body temperature to normal, it would measure as low as 97°.

(Urine was generally lessened in evacuation and quantity).

I would call the attention of the profession to what Dr. Veechere termed "Intestino-peritoneal Septicæmia;" another term is "Perforative Peritonitis." The autopsy of such cases shows a mottled peritoneum. The dog will often die in less than one day. The inflammation is not like diffuse or general peritonitis, but is circumscribed, limited, surrounded by

lighter and less affected spaces. The disease acts peculiar to itself. It is a local inflammation on the peritoneum, intesely active, having a purulent, putrid, thin, fluid exudate, more or less, with mottled variagated color. Firm adhesions do not exist, and the peritoneum is highly injected with blood, and often the gut is covered with a dirty, grayish, flaky, or fibrinous deposit. It is extensive and rapid when the perforation is large enough to pour considerable intestinal contents over the peritoneum. I do not think too much can be said of this variety of peritonitis, as it demands a distinct treatment. Dr. Veechere's term is a good one as it denotes its origin —"Intestino-peritoneal Septicæmia." Dr. Mikulicz calls it "Diffuse Septic Peritonitis." Now, death is so rapid and certain that, no time should be lost in opening the abdomen, thoroughly washing out the cavity with hot water, finding the perforation and suturing it. This is the only treatment worth acting on, and though single cases show brilliant results, it is generally unsatisfactory. The shock of such disease and the infection, are so rapid and progressive in nature, that death too often closes the scene.

I will now speak of another kind of peritonitis which was so many times demonstrated in the autopsies. This form of peritonitis started quite distinctly local, exactly in the neighborhood of the perforation or point of infection. A fibro-purulent exudate then arose which entirely encapsulated and surrounded the

infecting point in the beginning, so that the peritoneal adhesions prevented the infection from getting into the general peritoneal cavity, which as yet is pure and clean. Now the process steadily spreads, but Nature just as steadily attempts to protect the yet healthy peritoneum, by throwing out barriers of exudates which separate the infected from the non-infected peritoneum. The glued viscera hold encapsulated fibrin and pus in distinct cavities, while the other part of the peritoneum is yet unaffected. This is the kind of peritonitis in which is found puddles or cavities of pus and fibrin in different parts of the viscera in the abdomen. The treatment of this progressive fibro-purulent peritonitis, should be totally different from the previous one. In this case each puddle of encapsulated pus and fibrin should be opened separately and carefully washed out. It should be so done that the remaining part of the peritoneum will not be infected, as the disease is purely local. I have seen these puddles or encapsulated parts start in dogs, and become absorbed spontaneously. The infected point would be distinctly and carefully hemmed in and surrounded by a fibro-purulent exudate, and the lines of demarcation between healthy and diseased tissue would be distinct. The various stages, conditions, and kinds, of peritonitis, can be studied with much benefit in such experiments.

CHAPTER IV.

PERITONEAL ADHESIONS.

Lately surgeons, and especially gynæcologists, are beginning to appreciate the widespread adhesions which arise after most severe abdominal operations, from general, or particularly local, peritonitis. The intestines adhere to each other, to some of the viscera, or to the abdominal wall. These adhesions may give rise to intestinal obstruction. I am now convinced that intestinal adhesions after laparotomy are much more extensive and frequent than is generally believed. A large number of autopsies, carefully made on dogs on which laparotomy had been performed, demonstrated the fact that scarcely one had no adhesions. These adhesions were :

BAND, ADHESION, APERTURE, AND FLEXION.

I wish to present some ideas on the above four terms, so that operations on the peritoneum may become more significant and impressive than is generally accorded. Coleridge observed that more wonders were manifested in the first nine months of man's life than any subsequent nine; it may also be said, more wonders occur after abdominal operations than blind men groping in the dark can see. Spencer Wells lost 11 of 1,000 cases of ovariotomy from the above causes. Dr. Senn reports a case of abdominal stric-

ture originating after operation. Without specifying names, I have observed death throughout abdominal literature for the past ten years in considerable numbers. On some cases, performed operations have saved the patients. One-quarter of all intestinal obstruction is said to be caused by bands and operations. Any operator who has done abdominal operations, and then distinctly observed the autopsy at varying periods after operations, must have been highly impressed with the numerous and strong adhesions found. He is still more surprised, sometimes, to find several feet of small bowel fallen through a hole or aperture which was torn in the omentum.

These adhesions are of the most varied nature. Sometimes the omentum would be adherent to the whole length of the abdominal incision, and again it would extend its adhesions several inches on the parietes beyond the incision. It would be found very often attached at its edge or other locality to the repaired gut wound, forming an arch under which intestines could slip.

Gut was found more or less attached to all local inflammations within reach. It would glue one or several intestines together and hold them like a matted coil of ropes. At times the intestines were rolled in a ball with the omentum entwined among them. Again they would be found adherent to the stomach, spleen, kidney, liver, and especially to the mesentery. The adhesions were

varied in length; when short, kinks were apt to occur in the bowel; when long, the guts would often roll to and fro under the band made round by friction. Often the bent loops of intestines which frictionized each other, were solidly adherent, or an intestine was glued to the mesentery. Artificial obstruction and invagination gave rise to extensive local adhesions, which did not absorb readily, and often left cicatrices which presented appearances of permanence.

These old scars were treacherous, for they afterwards progressively hardened and contracted. Omental and intestinal adhesions were quite frequent along the abdominal incision. The sutures and extensive manipulation in this tract increased these adhesions. I used at first carbolic acid solutions, and believe it aids in increasing the adhesions from its destructive character and toxic tissue effects. Later I used simple hot water for the compresses, and adhesions seemed to lessen from its use. Finally, in cases of extensive examination and manipulation, I poured water into the peritoneal cavity as hot as I could bear the hand in, and think this aided in lessening adhesions. This one thing was demonstrated over and over again, that hot water poured into the peritoneal cavity distinctly lessened and counteracted shock in a very remarkable degree. The water left in the cavity was absorbed by the intercellular spaces and stomata existing in the peritoneum, and passed mainly by the kidney.

Two loops of gut would adhere together when no wound was visible. It is safe to say that a firm adhesion of the intestine can take place with but one wounded surface. The intestines, and especially the omentum, would contract firm adhesions to the stump of the wounds of those dogs from which I extirpated the spleen and kidney. Several months afterwards, the cicatrices would be found hard, white and contracted.

The autopsies demonstrated that the intestines, which in the first few days or even weeks contracted adhesions, became released and free by reason of the peristaltic movements of the gut. The intestines as they recovered from the operative shock, increased their vermicular vigor and tore away from each other. A month would clear up intestinal adhesions to intestine very much.

But this was not so with the omentum which contracted adhesions to viscera, parietes, or mesentery, and firmly held its grip. It formed bands and arcades of all kinds and shapes, which served as tempting traps to catch a wandering gut. Such bands sometimes whitened, hardened, and contracted.

It became a frequent occurrence to see an intestinal loop firmly attached to any raw surface left in the abdominal cavity. These remarks apply alike to man.

There is, of course, a difference in the location of the most frequent inflammations in dog and man.

In the dog they appear at the pendent portion of the abdomen, from his standing on four feet; while in man the worst inflammations occur most frequently in the pelvis. Over half the women are afflicted with it.

Taking the autopsies of dogs on which laparotomy had been performed, one learns two very impressive things which are all-important in the practice of surgery and medicine. One is the kind of adhesions which the intestines form with each other, with the viscera, or with the parietes; another kind is the omental mesenteric variety. The autopsies were done from one day to eighty days after the operations. It was very apparent that time had much to do with clearing up the kind of adhesions which involved the gut wall. The more peristaltic movements, the more the gut broke away from its attachments and promoted absorption. The first week, where inflammations of the intestinal walls arose, the whole or local parts of coils would be bathed and held down by exudates, and a few adhesions existed with viscera and parietes; but in the few following weeks, the rolls of intestines, glued together like a ball, quickly began to be freed from the exudate and assume an energetic peristaltic action. The adhesion from the viscera and parietes absorbed less fast; it required longer time to break them up. The dogs were kept in a small room and mostly tied so that they were fairly quiet.

The omental or mesenteric variety of adhesions

proved to be the more dangerous kind; these required weeks to absorb, even to a small amount, and are apt to form white, hard, constricted bands. I have seen left in one dog, no less than three distinct omental bands, variously attached, from three to fifteen inches long. Sometimes the bands lengthen by being drawn out into thin round cords forming arches under which intestines slide continually to and fro; by wear and friction of the bowels the bands have round and thickened edges. Of autopsies, more than 150, fully 70 per cent., had some form of adhesions left at the end of from two to eighty days. Many of the adhesions would never leave the animal, and would probably produce ill effects in his future life.

The peritoneal cavity should be molested as little as possible; all irritating substances should be avoided. Very little sponging should be done. The toilet if required should be done by pouring hot water into the abdominal cavity. All raw surfaces should be covered by omental grafts, as well as stumps of tumors. The omentum should be respread over the intestines.

It is my experience as derived from these experiments, that hot water poured in the belly will aid in preventing adhesions. Apertures in the mesentery or omentum, congenital or acquired, are a source of danger. The intestines with a long mesentery may slide backward and forward through such a hole for an indefinite time, until some mechanical difficulty arises from disease or indigestion, when strangulation

may occur. A few times, in performing gastro-enterostomies, the omentum, instead of being pushed to the left, was perforated to reach the stomach; the aperture was probably three by five inches. In two of these cases, seventeen to ten feet of small intestines were found prolapsed through the aperture. This would teach one not to perforate the omentum, but to take the graft from its right edge—or, better, sever the graft from the omentum. Among all the autopsies, comprising over 160, we found no aperture in the mesentery. Thin places could be seen, at times, in the mesentery, which would likely become a hole by some pressure accident. No diverticula were discovered. Meckel's diverticulum is more rare than is generally believed. The normal Meckel's diverticulum is the incomplete obliterated remains of the vitelline duct extending from the ilium to the umbillicus. Its average length is three inches. It most frequently exists as a blind pouch. As its free end floats in the abdominal cavity, it frequently found attachments to distant organs, thus creating an arch, under which intestines might be strangulated. Treves examined carefully 100 bodies, and did not see a case of Meckel's diverticulum. I have been present at several hundred post-mortems, and have not yet seen one. However, it is one of the many bands which may strangulate an intestine.

Strangulation by bands and through apertures, constitutes more than one fourth of all intestinal ob-

struction. It becomes an important study to demonstrate by experiment the cause and manner of growth of such structures.

The bands arise from local and general peritonitis, or are the results of unobliterated fœtal structures.

Sir Spencer Wells reports 11 deaths from intestestinal obstruction caused by bands in 1000 cases of laparotomy. Martin, Mueller, Senn, and others, report similar cases.

It thus behooves surgeons to use the best known means to prevent the arising of those bands after operations pertaining to the abdomen. The pouring of the abdominal cavity full of water as hot as the hand can bear, seems to me to be a rational method, as proved from the autopsies on the dogs. The water should be left in the cavity to act as a bed in keeping the intestines separate, and viscera and omentum. Statistics would seem to show that over 70 per cent. of all persons who suffer from intestinal strangulation by bands, have a history of peritonitis. No doubt there will come a time when the abdominal cavity will be irrigated by hot water for peritonitis, which will save life and prevent dangerous adhesions.

As the average duration of life under strangulated intestines by bands and through apertures is less than a week, it behooves the surgeon to make an early diagnosis, and apply the best technique to save the patient's life.

The operative treatment for strangulated intes-

tines under bands and through apertures is generally a simple matter, but if gangrene has occurred, rings and plates is the rational way to finish the operation. A surgeon told me a short time ago that he operated on a man for intestinal obstruction, and found a piece of gut under a band. It was the eighth day, and the gut was black. The surgeon released the gut, but he said he did not know what else to do. The patient died of perforative peritonitis in a few days. His diagnosis was correct, but his technique was a failure.

If the vermiform appendix is long, it may act like any other band and strangulate a gut. Many such cases are on record.

The whole matter rests on knowing how to make, a diagnosis of obstruction, and to be able to use proper technique in the operation.

The urachus, the obliterated hypogastric arteries, and the round ligament of the liver, may be recorded as aiding to obstruct the gut. Littre's hernia will cause obstruction; this is really a paralysis, as a part of the circumference of the bowel is nipped by adhesion, and the intestine loses its peristaltic action. The lumen of the gut may be undisturbed.

Kinking of a gut seldom causes obstruction, but if a long gut drops on a band, like a tube hung over a wire, it will prevent fæcal passages.

Any one of the various classes of peritoneal adhesions, when it gives rise to intestinal obstruction, assumes an acute type, and unless relieved by operative

measures, generally becomes fatal in about a week; the fatality is not due to merely closing the lumen of the bowel, but to gangrene of the gut caused by shutting off the return of venous blood. I have seen gangrene in a woman from femoral hernia in 12 hours. Gangrene appeared in one dog in 10 hours, caused by the intestinal obstruction preventing the flow of venous blood.

These various kinds of adhesions give rise to a variety of methods by which a gut can become obstructed and strangulated, but the effect is almost always identical on the obstructed intestine viz.: Gangrene.

Seldom did an autopsy of a dog show any part involved but the small intestine. It is the same in man. Intra-abdominal and extra-abdominal hernia nearly always involves the small bowel.

Any hernia of the large bowel is rare. However, I once made an autopsy of a woman who had such an elongated mesentery that I could draw the transverse colon about four inches below the femoral rings, and the sigmoid flexure had a mesentery so long I could draw it across the pelvis through the right femoral and inguinal rings; but such are very rare. It seems that it is well to observe that strangulated hernia and intestinal obstruction are one and the same kind of disease, and differ from each other only in their anatomical location; their clinical history is generally the same.

One dog exhibited a dangerous narrowing of a gut lumen from inflammation excited in a mesenteric gland immediately adjacent to an operation. The gland was involved in the operation, and in a short time it so swelled that the gut lumen was about as large as a lead pencil.

It appears that the ilio-cœcal region of a dog is subject to the same weakness as that of man, for after operations it was more frequent to find adhesions clustered round this historic valve. It appears to act in a dog as it does in man—as a physiological anus.

A medical friend of mine, opened a man for obstruction of the bowel, and found that the peritoneum had so strongly contracted on the bowel that only a knitting-needle could pass, and the length of gut was so extreme in the adhesion that he did not dare to resect it. The cause was an old diarrhœa, involving the mesenteric glands. He closed the abdomen, and the patient died from marasmus in six weeks. Had he been familiar with rawhide plates, or rubber plates and rings, the patient could likely have been saved by anastomosis, leaving the contracted gut in the belly.

The location of attachments of the adhesions arising from local or general inflammation of the peritoneum, differ from physical positions. The dog stands on his four feet, and the laws of gravity will decide the location of the heavier organs to be at the most pendant portion of the belly. This will be the position of the inflammation and its products in a

dog. But it is different with man, as he stands upon his hind feet. When man fell, he fell upward. The force of gravity crowds the organs in the pelvis. This will decide location of man's inflammation and its products.

The difficulty of diagnosing diaphragmatic hernia is shown in a report of 250 cases; it was recognized but five times. Thus it can be seen that the diagnosis of internal hernia or strangulation is very difficult.

FLEXIONS.

During the operative experiments, I made almost every conceivable variety of flexion and kink, at all possible angles compatible with the life of the tissue at the seat of action, but in none did obstruction occur; the bowel accommodated itself to its environments, and soon yielded to form a lumen necessary for required functions. Flexion or kink does not produce ordinary stenosis, but a kind of valvular closure caused by pressure of the bowel contents of the proximal part against the distal limb of the distal part of the gut. The causative element of obstruction lies wholly on the distal side of the flexion. Inflammation at the seat of flexion might give rise to exudation resulting in cicatricial stenosis. These flexions may arise after strangulated hernia, as in this case. Littre's hernia could arise by the flexion being adherent to some surface, as the abdominal wall. A gut in this position cannot perform peristaltic movements,

and hence obstruction occurs. Recent reports of intestinal obstructions are quite numerous following operations. As the mortality of secondary operations for the release of strangulated intestines is very high, all possible prophylaxis should be employed. The one thing needful is *cleanliness.*

CHAPTER V.

THE DIAGNOSIS OF INTESTINAL OBSTRUCTION.

The diagnosis of intestinal obstruction may be considered the most obscure in the field of clinical medicine. Any kind of diagnosis of intestinal occlusion except by laparotomy, must be by inductive reasoning or exclusion. The obstruction must be situated in the wall, in the lumen, or external to the intestinal canal. General consideration of the whole subject is important. Carefully collected statistics of autopsies aid in referring to the main kinds and features of the most common forms. It will be necessary to utilize and apply all known anatomical and physiological knowledge to every case under consideration.

The assiduous cultivation of any subject is an indication of its own importance. No three years since the world began, has beheld such devotion to the improvement of intestinal diagnosis and technique as the past three. Heretofore the study of intestinal diagnosis was neglected, as physicians possessed no technique to execute such diagnosis. Men, in general, will not cultivate a branch of knowledge unless there is some utility in it for mankind, or unless there is a promise of financial reward. The present improved technique will stimulate clinical observation and ex-

periment, which are, respectively, the rock and base on which rests diagnosis. The frightful mortality, in the past, of intestinal obstruction, has been mainly due to late diagnosis, and imperfect technique. The frequency of death from occlusion of the bowel also commands attention. It may be considered good calculation to place 1 death in every 350 as due to intestinal obstruction.

We cannot be mathematically accurate in the statistics of the subject, but much information can be gained by general and recognized figures. I will deal with 16,000 fatal cases of intestinal ob-obstruction, collected from all sources at command, and make a basis of division on the number 40. Under this fraction, it will be shown that invagination will represent $\frac{15}{40}$ of all intestinal occlusions, or about one-third of all cases.

The seat of invagination may be represented by allowing 50 per cent. for the cœcal region, 30 per cent. for the small intestine, and 20 per cent. in the colon. It is estimated that one-third of all the invaginations, occurring at the cœcum, reach the rectum. Blood occurs in the stool of 80 per cent. of cases of invagination.

After leaving out the "invagination of death," it will be found that intussusception is a disease of childhood; 25 per cent. of cases occur in the first year of age, and 50 per cent. takes place under ten years of age. The mode of onset is sudden in 75 per cent.

The fraction which represents intestinal obstruction by strangulation under bands, and through apertures, is $\frac{10}{40}$, or one-fourth of all cases. Ninety per cent. of strangulations occur in the small intestine, and 10 per cent. take place in the large intestine. It is shown that 70 per cent. of persons who suffer from strangulation under bands and through apertures, have had peritonitis; hence invagination and strangulation under bands and through apertures constitutes $\frac{25}{40}$ of all bowel obstruction. Men are more liable to suffer from these two causes than women.

Volvulus will be represented by $\frac{2}{40}$ of all cases of bowel obstruction. Sixty per cent. of volvulus occur at the sigmoid flxure, 30 per cent. at the cœcal region, and 10 per cent. in the small intestine.

Volvulus is four times as frequent in men as in women; appears mostly in men over forty years old. It occurs in persons with a history of constipation, and elongated mesentery having little fat in it. A volvulus has its peculiar manner of formation, as among animals I was unable to form one and retain it, even by fixing by sutures, so as to produce an occlusion. Gall-stones form $\frac{1}{40}$ of intestinal obstruction, and are four times as frequent in women as in men; they occur mostly after thirty-five years of age, and autopsies show they are fatal only in small intestines. They pass from the gall-bladder through the gall-duct, or through an artificial opening formed

by ulceration through the gall-bladder and intestinal wall.

Enteroliths and foreign bodies represent $\frac{1}{40}$ of obstruction. These bodies, called *Bezoars*, among animals are formed around some foreign substance, such as a piece of bone or metal I saw one from the cœcum of a horse about the size of a prairie-chicken's egg. It had formed itself around a piece of tin such as glaziers use to hold a pane of glass in the sash before the putty is applied. The main bases of enteroliths, are: Calcium, magnesium, ammonium, and phosphorous. Real foreign bodies swallowed have a history. Ilius paralyticus may be represented by $\frac{3}{40}$ of occlusions. The mass of fæces can almost always be felt in the abdomen, which dents and retains the dent, and gives to the fingers the feeling of dough. A history of previous constipation points to a conclusion; it occurs mostly in women, persons suffering from some form of nervous disease. It may be from some form of peritonitis, and by the disappearance of the latter the patient recovers from the paralysis of the intestine. Many forms of chronic constipation are simply a paresis of the bowel. Stricture will make up $\frac{3}{40}$ of bowel occlusion. Eighty per cent. of strictures occur in the colon, and 20 per cent. in the small intestine. This shows that there are four times as many strictures in the colon as there are in the small gut. In 98 strictures of the colon, 58 occurred at the sigmoid flexure.

Intestinal strictures affect females much more than males. According to one table of 1500 cases, women suffered twice as often as men. After the sigmoid flexure, the descending colon suffers most, then the flexures of the colon, and finally the cœcum and ileo-cœcal valve. Stenosis of the bowel does not frequently follow typhoid fever. Stricture often follows dysentery, and almost always in the large bowel. Foreign bodies swallowed may injure the bowel, so that stricture will follow. The peritoneal contraction, when the bowel is squeezed to the size of a lead pencil and held firmly against the posterior abdominal wall, nearly always occurs in the small intestine. I saw one case in which the mesentery was rigidly contracted to the abdominal wall, and the intestine narrowed to the size of a lead pencil for about ten inches; it followed a chronic diarrhœa contracted in the late war. The history of any disease of the intestines, but especially any form of ulceration, loss of tissue by injury or gangrene and dysentery, must not be lost sight of. Strictures of the large intestine are generally single, while in the small intestine they may be many, and in operation; this should not be forgotten. Strictures are at times slow in growth; I know of one troubling a man twelve years before it killed him. Most strictures affecting the wall of the intestine, are cicatricial, or cancerous. I wish to note a peculiarity which I found in strictures of the large bowel, and that is, when the stricture is even in

the sigmoid flexure, one can detect the main fæcal mass in the cœcum. In one case I diagnosed obstruction in the cœcal region from a large fæcal mass palpated there, and the autopsy showed cancerous stricture at the junction of the sigmoid with colon, but the fæcal mass was still in the cœcum and ascending colon. Neoplasms form $\frac{5}{40}$ of bowel obstruction, but almost all are of cancerous nature. The polypus is the main innocent neoplasm, and is found mostly in the rectum. The best statistics show that 80 per cent. of cancer of the intestines is located in the rectum, 15 per cent. in the colon, and 5 per cent. in the small intestine. Leichtensten shows that out of 34,523 deaths in the Vienna Hospital in twelve years, $5\frac{8}{8}$ per cent. were due to cancer. He shows that cancer caused death 178 times in 1541 cases of intestinal obstruction, which makes cancer cover more than 11 per cent. in bowel occlusion. This does not include stomachic cancer, because Virchow shows that the stomach is attacked more by cancer than any other organ in the body, amounting as high as 34 per cent. of all cancers. Many cancerous strictures cause blood to be passed in the stool, which should not be confused with invagination.

Cancer of the intestines is often fatal in a few months. Obstruction of the intestine by compression may arise from adhesions, enlarged viscera, and tumors. The most fixed parts of the intestines suffer the most. It constitutes about $\frac{8}{40}$ of occlusions.

Congenital occlusion of the bowel occurs, according to statistics, about once in 20,000 births; and reference to the table below will show at a glance some of the forms, locations, and percentages of kinds of intestinal occlusion, compiled and care-

NAME.	PROPORTION OF OCCLUSION.	SEAT OF OCCLUSION.					
		Pylorus.	Cœcum.	Colon.	Small Intestine.	Rectum.	Sigmoid Flexure.
		)	Per	cent	age.	(	)
Invagination	15/40	....	50	20	30	....	....
Strangulation by bands and apertures.....	10/40	....	....	10	90	....	....
Volvulus.....	8/40	....	30	....	10	....	60
Gall stone	1/40	....	....	....	100	...	....
Enterolith and foreign bodies.....	1/40	....	....	....	...	....	....
Stricture.....	2/40	....	....	80	20	....	....
Neoplasm	5/40	....	....	....	....	....	....
Compression.....	2/40	....	....	....	....	....	....
Ileus paralyticus	2/40	....	....	....	....	....	....
Cancer	.....	(34)	....	15	5	80	....
Congenital	.....	One in 20,000 births.					

fully worked out of a large number of writers. The table is not mathematically exact, but approximates truth. To the busy practitioner, it will be convenient in order to gain a large field of general knowledge in a short time. The above are general views; they are the results of classified knowledge gained at autopsies. They become the basis for abstract reasoning which can be applied to future substantial cases. Though the above represent natural facts, yet they are difficult to apply to concrete cases, which, being in imminent danger of life, require definite action on the part of the operator. In the diagnosis of obstruction of the bowels, one must appeal to ætiology, cause and effect, history, age, sex, avocation, and particularly the present condition of the patient. It is of supreme importance to know whether a patient has had peritonitis, strangulated hernia, or mesenteric gland disease, as each will jeopardize his life to dangerous attacks of bowel obstruction. I have seen a mesenteric gland almost close the lumen of a dog's intestine a few weeks after operation, and peritonitis has made such invasions on the intestines in a month that I wondered how fæces could possibly find passage through the solid bundle of coils, kinked and flexed, bound together by strong adhesions, the gut lumen often much narrowed, and the whole intestines in one bunch, lying in the great omentum like a sleeper in a hammock.

The four most prominent and almost constant

symptoms which can be applied to concrete cases are pain, vomiting, constipation, and tympanites. Complete absence of stools and resistance to purgatives is a suggestive element in intestinal obstruction. A patient may have stools from below the obstruction, but that is merely spurious diarrhœa. However, it must be remembered that man can go without stool several weeks, and not suffer from obstruction in its definite sense; cases are reported as having gone 18 weeks. When the vomit includes fæcal matter, suspicion points to occlusion. It must not be forgotten that a bi-mucous fistula may exist between the colon and the upper part of the small intestines, through which fæcal matter can easily escape into the stomach. The sudden, rapid, and continuous accumulation of gas in the bowels, indicates acute strangulation of the alimentary canal. The pain is the result of injury to the peritoneum and bowel, also to irregular and violent peristalsis. A call to a patient impresses a physician most profoundly: The patient is in pain, pale, and breathing irregularly; he has shock bordering on collapse. The physician examines the abdomen, inquires into the progress of the disease, and ascertains the history and condition of the patient; the rectum is explored (and vagina if a woman); he is so pale that he may be thought to be losing blood; a slight stool has passed, probably from reflex irritation, but no gas; he vomits, and is quite restless. The doctor perceives that the patient is

quite sick, and goes away with no definite diagnosis, but is full of uncertainty and perplexity. The proper plan to pursue is to re-examine the abdomen, and to repeat the process, and persist in the study of the case until some distinct conclusion is reached. The rectum should be explored, if required, with the whole hand introduced under an anæsthetic. With the arm so introduced, one can palpate the organs of the abdominal cavity to a considerable extent. Thus the rectum and the sigmoid flexure are the points most liable to disease, of all the intestinal tract, except the pylorus, which will be excluded from the field of probability. Injections of large enemata are of little value for diagnostic purposes, as the lower bowel may be relaxed or contracted, and practical cases have proven that a stricture may allow fluid to pass up but not down. Any one can prove on the cadaver that the long tube is almost useless on account of its curling upon itself, and also on account of the varying condition of the sigmoid flexure. It may be long with an elongated mesentery; the long tube could hence go into it, and the point may be felt at the umbilicus without entering the descending colon. I performed autopsy on one case with a sigmoid 21 inches long, and a mesentery about 14 inches. In such cases men are deceived in thinking their hand enters the descending colon, when it does not even reach the superior end of the sigmoid flexure. Auscultation of the colon with fluid or gas passing through it,

will be of great service; one can hear the hydrogen gas roaring as it passes through Bauhin's valve, or a stream of fluid can be distinguished as it proceeds along the colon. It requires some practice to detect these sounds, but a few experiments on cadavers and dogs will give much aid. A friend, skilled in abdominal work, should be requested to examine the patient. He may suggest valuable information, but one must rely on his own responsibility, as that alone begets usefulness. Here is where knowledge is power, but a *little* knowledge a dangerous thing.

A case came to my observation where a doctor allowed a patient to bleed to death under the name of peritonitis. The autopsy proved it to be a ten week's ectopic pregnancy. Time is the all-important element in intestinal surgery for obstruction. The abdominal surgeon should so cultivate his branch that he can discern when mischief is afoot, and sufficiently early for an operation before destruction of tissue has complicated or rendered it irrepairable. A notable feature of sudden occlusion of the bowels is shock.

Shock is a profound impression on the nerve-centres. It is carried mainly through the sympathetic system—the three splanchnics and pneumogastic,—to the medulla oblongata, and affects particularly the automatic centres of circulation and respiration. An ideal nervous system consists of a ganglion cell, a conducting cord, and a periphery. Now, the cause

of this shock is an injury to the peritoneum and gut-wall which contains that part of the nervous system called the periphery. In the mesentery and gut-wall are situated large nerve plexus, such as the solar and hypogastric. Auerbach's and Meissner's plexus belong more intimately to the bowel-wall. The paleness in the shock consist in a disturbance of the circulatory automatic center in the medulla, and manifests itself by contraction of blood-vessels, distant from the abdominal organs, and by a profound dilatation of the blood-vessels of the abdominal cavity. A man can bleed to death in his own abdominal blood-vessels.

The irritation of the nervous periphery from strangulation induces a paresis of the walls of the blood-vessels. Blood stasis and engorgement result from loss of contractility of the vessel's wall, and diminished tonicity. The degree of shock will depend upon the amount of peritoneum and gut-wall injured or strangulated. It also depends on its suddenness, and peculiarity of the individual. In general, the most profound shocks arise from affections of the bowel nearest the stomach. This is from physiological reasons. Blood, nerve, lymph, and nutrition, are more extensive and active in the small than the large intestine. The small intestine is the laboratory of digestion, while the large intestine is the receptacle of waste.

Pain in intestinal occlusion depends mainly on

two conditions—merely cutting off the lumen of the gut or stopping the fæcal circulation does not cause pain. The first condition is the extent of peritoneum and gut wall damaged. The other is the irregular and violent peristaltic action of the intestines. From the lesion will arise excitable reflex action and vigorous peristalsis of the bowels.

I would call attention to the subject of pain as manifested by dogs having complete obstruction by a band of gauze tied round the gut, and those dogs having incomplete obstruction by invagination. The dogs with complete obstruction seemed to have constant pain; they gagged at every movement, and seemed under constant irritation; while the dogs with invagination had intermittent pain—invagination mostly forms incomplete occlusion; they had periods of repose and exacerbation. Hence, complete obstruction produces constant pain, and incomplete obstruction produces intermittent pain. This will be of special aid in diagnosis in the beginning of intestinal obstruction. As the disease progresses, the pain will become more constant in all forms. Diminishing pain may be looked on as a recovery, or paralysis of the nerves unfitting them to receive impression or provoke peristalsis. An increase in pain depends on reflex action and peristaltic movements, caused by food, action, and examination. There is no reliability in locating intestinal obstruction by the locality of the pain; it is in

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general referred to the umbilicus in the locality of which is situated the great solar plexus. One may sometimes locate disease by pain in the stomach or colon, but this is at all times uncertain. In strangulation, the urine will often lessen in quantity and quality, which arises from diminished blood pressure in arteries and veins from impaired heart action. Vomiting, when it includes real fæcal matter, is of some diagnostic value. Cases are reported in which a bimucous fistula existed between the colon and upper part of the small intestine; in such stercoraceous vomiting would lose all signification of obstruction. Vomiting is mainly due to peristaltic and reflex action. Peristalsis with a distended intestine above the obstruction, will simply drive the contents out of the mouth by the law of pressure, just as one may press on the stomach of a three months' babe and force milk out of its mouth; the stomach offers the direction of the least resistance—I do not believe anti-peristalsis is a factor worth discussing in intestinal obstruction. Some persons will vomit on seeing a poor dead fly in the soup. Here there is no obstruction, but peristalsis and reflex action tell the story; there is sufficient normal resistance in the alimentary tract to produce a wave of regurgitation. The diagnosis of the different forms of obstruction is but seldom possible. The list of bowel occlusions is very large, and there are so many symptoms common to different forms of obstruction,

that error is frequent. Pain, vomiting and constipation are common to about all bowel occlusions. Blood in the stool, and a tumor felt at the rectum of a child, would aid us in diagnosing ileo-cœcal invagination. Rapid accumulation of gas in a man above 40, who had suffered from constipation and was spare, might suggest volvulus of the sigmoid flexure. Dividing the obstruction into acute and chronic is simply arbitrary. Some consider the affair chronic after 20 days, and the chronic may become acute at any time. Stricture of the intestine is manifest by constipation alternating with diarrhœa, and at definite periods complete obstruction arising. Cancerous strictures may show blood in the stool, thus confusing with invagination or neoplasm; but here age aids. Obstructions from fæcal accumulation occur mostly in women who have long suffered from constipation, in short elderly persons who have had more or less chronic or habitual constipation, and especially those suffering from most nervous diseases. It is generally paresis of the bowel wall from central or local lesion of the nervous system. This form can generally be diagnosed by its history and an existing fæcal tumor.

A physician related to me a short time since an autopsy of such a case, where a fæcal tumor existed for months, and the woman obtained stool by having a tunnel bored through the center of the fæcal mass; the tunnel became mecanically closed, accidentally, and she died. The fæcal mass showed

a distinct cast or form of the colon. Mechanical and physiological accidents, as undigested accumulations, may exacerbate a chronic into an acute case. It is stated that the most common varieties of chronic obstruction are those of fæcal accumulation and stricture of the colon. It should be well remembered that constipation or fæcal accumulation does not always depend on narrowing of the gut lumen, but very often on what is called *ilius paralyticus*. In cases of invagination, fluids will pass for an indefinite time, but the narrow passage endangers life from mechanical accident.

Another consideration arises as to the diagnosis of obstruction in the large and small bowel. This is an attempt at differential diagnosis. If one can reach the tumor through the rectum or vagina, or can auscultate the colon by the aid of gas or fluid, a fair clue may be gained; but most methods are a little uncertain as to seat, and quite uncertain as to cause of occlusion. When applied to concrete cases, one can speak very reasonable from a physiological point of view in the abstract.

The small intestine is vigorously engaged in assimilating the main part of the food in the body, and is closely connected with the nervous system. It is presided over by the superior mesenteric plexus, the main part of the great solar plexus. Auerbach's and Meissner's plexus are large and numerous, and have a powerful nerve supply. Their lymphatic glands

and lacteals are active and extensive, and they have an enormous blood supply from the superior mesenteric artery. Their muscular walls are thick and mucous glands many; fæcal circulation is rapid.

On the other hand, the large intestine is a passive waste receptacle, only discharging its contents periodically, when over distended, and having a slow fæcal circulation. It is supplied mainly by the small inferior mesenteric plexus, same of the hypogastric, and same of the solar; Auerbach's and Meissner's plexus are not very large. Their nerve supply is much less than the small intestine, and the blood-supply is from the small inferior and part of the superior artery; lymphatic glands, lacteals, and muscle, are all less than in the small intestine. The anatomical physiology in this case teaches that any disturbance in the small intestine, or any obstruction, would be accompanied by a high degree of vascular, lymphatic, nervous, and muscular change. It would be violent and rapid, while obstruction in the large intestine would be from structure and function, slow, and pursue a mild course. This is so in general, and would be so in particular, but that the peritoneum plays a most important rôle.

The nerves are distributed over all the peritoneum alike, and the large intestine has more surface of peritoneum over it than the small intestine, so that what is lost by function and structure is made up by extent of peritoneum; but in general obstruction is

more acute and violent in the small than in the large intestine.

Obstructions in the colon tend to assume a more chronic form than do those in the small intestine. Some kinds of occlusion run just as rapid a course in the large as in the small intestine. Volvulus of the sigmoid may run a rapid, violent course, such as would occlusion of the ilium—strangulated by bands.

Finally, it must be noted that the clinical difference between obstruction of the large and small bowel, is not very reliable in concrete cases. Morbid symptoms occur, as a rule, earlier, and more quickly reach a climax, in the small than in the large intestine. But the salient feature in intestinal obstruction is, the mechanical lesion inflicted on the peritoneum. Obstruction of the bowel has been confused with a number of diseases which I will enumerate as collected from a wide source:

1. Hernia.—It should never be neglected to examine a patient in all the hernial orifices; inspection of the umbilicus, femoral, inguinal, obdurator, and sciatic orifices, should take place:

2. The paralyzed intestine must not be confused with obstruction; paralysis can be direct or indirect:

3. Reflex irritation, as crushed testicle, boil on abdomen: the irritation from sutures on the dog's abdomen cause retention of urine and constiptation for several days:

4. Peritonitis.—It is often impossible to differentiate peritonitis from acute strangulation (I performed laparotomy on a case which had been diagnosed as bowel obstruction on the left side, which proved to be local peritonitis caused by the rupture of an abscess of a mesenteric gland situated at the middle of the sigmoid; I once, also saw a physician diagnose peritonitis as a "ruptured gut)":

5. The rupture of the tube in ectopic pregnancy may be mistaken for bowel obstruction:

6. Lead colic, hepatic and renal colic:

7. Cholera:

8. Meningitis, typhoid fever or its ulcers, dysentery:

8. Arsenical poisoning:

10. Appendicitis:

11. Cancer or cysts of omentum or mesentery:

12. Liver cirrhosis:

13. Enlarged abdominal viscera.

It may be stated, in general, that any bowel obstruction that can originate of itself, can also disappear: I could not hold in position, even by stitches, invaginations in one-fourth of the dogs; disinvagination occurred without sutures in from a few minutes to a few hours, or possibly longer; volvulus returned even with suturing and did not produce obstruction; in operating I have produced severe kinking, but it always righted itself, as the autopsy showed.

"The most common termination of occlusions of the intestines is by fatal general peritonitis with or without perforation."—(Leichrtenstein). Animal experimentation clearly demonstrates that perforation kills many times from profound shock and infection, without general peritonitis. I saw a young woman die from rupture of an abscess into the abdominal cavity, in five hours; at the autopsy no general peritonitis was present, so far as I could see.

Temperature, from showing some peculiarity, is too often discredited as of little value in abdominal operations. It appears to me that temperature is of equal importance in abdominal work as in any field. I believe the fever is caused by oxidation of some toxic substance in the blood. Man's blood is kept at 98½ degrees by oxidation, which is controlled by the heat centers residing in the nervous system. Any higher or lower than 98½ degrees is due to a variation of oxidation of the tissue called blood. In high fever, oxidation is rapid. The heart quickens its pace so that the blood stream will have an opportunity to get as much of its toxic substance oxidised in as short time as possible. Now, in many cases of abdominal diseases, perforative peritonitis, in profound infection of the peritoneum, the temperature is below normal. This is simply because oxidation is not rapid enough to consume the toxic substance in the blood, The blood tissue is simply overwhelmed and flooded with the poison. If oxidation is not sufficient or

rapid enough to bring the temperature to 98½, the patient will die from lack of oxidation. Abnormal temperature or fever is an excess of oxidation of the toxic substance in the blood. The thermometer is the only guide to either condition. Every dog which died, whose temperature was taken, had abnormal temperature at some time in his disease. Shock alone often gives a subnormal temperature.

CHAPTER VI.

LAPAROTOMY FOR INTESTINAL OBSTRUCTION.

The object of opening the abdomen for occlusion of the bowels is, to find the cause. The cause must be carefully examined, its nature and location determined, and must either be removed or rendered harmless. The operation must be for a high purpose and not merely to solve a diagnostic puzzle. If the cause cannot be removed without interrupting the continuity of the intestinal canal, the operator must perform an artificial anus, circular or oblique enterorrhaphy, or intestinal anastomosis; every one of these propositions may be accompanied with grave difficulties. The first proposition is to find the cause of obstruction. This is not infrequently the most difficult part of the operation. I noted the records of almost 40 cases where the surgeon was obliged to close the abdomen without finding the cause of obstruction or its nature.

The subject is well illustrated by Prof. Madelung. When patients died in the hospital from intestinal occlusion without an operation, he would request the pathologist to open the abdomen sufficient to allow the introduction of the hand, and then allow him 20 minutes to make a diagnosis. In no case does the report announce that the pathologist found it. If a trained pathologist, without fear of injury to the pa-

tient, with his hand in the belly, is unable to make a diagnosis or even discover the seat of obstruction in 20 minutes, the obstacle will be almost insurmountable to the non-expert. In artificial obstruction and invagination produced on dogs, Dr. Gillette and myself made a number of experiments to satisfy ourselves of a man's power in locating intestinal obstruction by intra-abdominal examination. The dog's abdomen was opened and a loop of intestine drawn out, and either invaginated and fixed in position by several sutures, or a piece of aseptic gauze tied sufficiently tight around the gut to obstruct its lumen. The abdomen was then closed. Some three days after, the dog's belly was reopened large enough to admit the hand to examine the whole cavity. Several times by careful trial of both, we were unable by intra-abdominal examination, to locate the seat of obstruction, at other times we could locate it with certainty. This presentation may appear as an exaggeration of the difficulty of discovering the cause of obstruction, but I would suggest a trial before criticism blinds the eyes to facts. Cases are reported where a part of the obstruction was discovered and removed, but the undiscovered part killed the patient. Examples may be cited of multiple strictures and bands, or gunshot wounds. It is well to remember, in searching for intestinal obstruction, that it generally lies below the umbilicus, in the right or left groin or in the pelvis. The most general and best direction

given, is to first find the cœcum and determine its condition. If the cœcum is distended with fluid, gas, or fæces, the obstruction will be further down the colon, which can be followed by the hand to the sigmoid flexure. This is the second point which should be examined carefully, and also the rectum should be explored. If the cœcum is empty or collapsed, the ilium should be gently followed to the point of obstruction. All this manipulation may be futile, and give not one distinct idea of the nature and seat of the occlusion. The appearance of the intestine should be carefully observed; above the obstruction it is distended, congested, bright and fresh, or dark and blue. The distended coils rise highest in the belly, and do not occupy the pelvis, while the collapsed, empty, small intestines drop down in the pelvis. The coils may show, by the nature of their contents, the proximity of the obstruction. If the contents are fluid fæces, it might indicate proximity, but if gas, more distant. But experiments on dogs demonstrated that this was not always reliable. The full intestines, as they bent and kinked on each other, narrowed their own lumen, and thus produced a kind of automatic obstruction. It is also often impossible to follow distended coils with the hand in the belly, and it is dangerous, for such coils have friable walls which rupture easily. Again, one will drop the highly distended coils to attempt to follow the gut which appears more collapsed and of a more natural color;

such coils, being heavier, and smaller in size, are forced by gravity to low points, especially the pelvis. The operator thus tries to follow up a collapsed gut to the seat of obstruction. This may also fail. The next method is to have an assistant seize a coil of intestine between his finger and thumb, so as to locate the starting point, and then the operator can pass the gut, inch by inch, through his fingers, and gently tuck it back into the belly as he goes along. This is quite a certain (manual and occular) method, but the shock is very great, and might kill a patient. Again, the intestines may be so distended that it is almost impossible to search for the cause with any effect. In such cases the bowel should be incised on its convex side, and its contents evacuated as much as possible, and the wound sutured. It avoids the risk of danger by rupture. The gut will only empty in general to the first kink, but by manipulation and the use of a long rubber tube, much more can be emptied. If this prove a failure, exventration should be practiced. Much has been said against this procedure, but experiments on animals seemed to me to demonstrate that it is without sufficient foundation. In exventration the intestines will often increase in size by the development of gas, undoubtedly from the removal of the pressure of the abdominal walls. The distended intestines are then often difficult to return to the abdominal cavity, but by uniform, continued pressure on compresses, and aided by hooks drawing

upward the abdominal wall, and beginning the sutures from above, reduction is finally accomplished. If reduction is impossible, the bowel should be incised and its contents emptied, and the wound sutured with a Lembert suture. The exventration allows of easy and rapid examination. The intestines need not be bruised or injured by being accessible to touch or visible to the eye. If all the above methods fail, what is to be done? I would strongly oppose the formation of an artificial anus, as such patients are doomed to a life of loathsomeness. Try the process of hunting for the lowest point of the distended bowel, and mark it, with a rubber band pushed through the mesentery and tied around the gut. Then inflate the rectum with hydrogen gas or air, and note how high the gas rises in the intestinal tube, and locate it with a rubber band. Now perform an anastomosis between the distal and proximal gut of the obstruction with raw-hide plates. This will relieve, prolong life, and exclude but little of the canal. All methods may fail to find any local obstruction because it is obstruction from paralysis induced by peritonitis or central nerve lesion. The proper method to find the seat of intestinal obstruction is by manipulation and ocular examination, and if required, exventration. The bowel above the obstruction is distended and congested, while that below is pale and contracted. This is important, as the rapid or sudden development of gas in the intestines is one of the important symptoms of obstruction.

The whole of the examination should be done gently, rapidly and systematically, as time is an essential element to success in all intestinal surgery. A good knowledge of the anatomy of the abdominal viscera and their relations, is requisite to proper examination.

The intestines should not drag too heavily on the mesentery, as it shocks the animal severely. I think two dogs died from this form of shock.

The second point in laparotomy for intestinal obstruction is, to remove the cause or render it harmless. The essential thing is to determine the nature of the cause. It may be invagination, strangulation by bands or through apertures, volvulus, gall-stone, an enterolith, impacted fæces, a stricture, or any physiological or mechanical obstacle capable of interrupting the fæcal circulation. Some causes of obstruction are harmless in themselves, as a non-malignant stricture, and therefore could be left in place. Others, such as cancer, will ultimately destroy life. Some would endanger life by liability to gangrene or perforation, *e. g.*, intussusception and gall-stone. A ligamentous band is in itself not offensive, but acts as a continual menance for further danger. A gangrenous gut would cause peritonitis. It is thus seen that some causes must be removed to allow life to continue, while others may remain *in situ*. The modern method of *intestinal anastomosis* has rendered this possible and easy of execution by the use of raw

hide or segmented rubber plates. I know of quite a number of laparotomies done by neighboring physicians for intestinal obstruction, where was found simply a longitudinal stricture caused by some mesenteric gland disease, and though done the past two years and since anastomotic plates have become well known, the abdomen was closed on doomed patients. These patients could have been cured with raw hide or rubber plates, by anastomosing the gut above to the gut below the obstruction. Some of the causes of intestinal occlusion will require formidable operations with complicated technique, as the removal of most causes destroys the continuity of the alimentary canal. Several methods are open to action. The gut can be divided above the seat of obstruction and conducted through some point of the abdominal wall as an artificial anus. The distal bowel end can be invaginated, sutured, and left with its harmless cause. Again the obstruction may be removed by resection and the bowel ends invaginated, and anastomosed with plates. If it be found necessary to exclude a piece of gut from the fæcal circulation, it is not at all necessary to resect it. I have left nearly five feet of gut in the abdomen and even filled it with fæces before the two ends were invaginated and sutured. The dog ate and lived well in that condition. Resection is a dangerous process. Irreducible invagination or volvulus should be left as found, if not gangrenous,

and the intestine rendered permeable by lateral anastomosis with plates. Cancer, from its nature, might well share the non-disturbance. Early operations would avoid the complicated and formidable operations required when gangrene or perforation had occurred. The operation par excellence is anastomosis. A gall stone might be crushed by a needle introduced into the gut lumen without further operation. A spot of gangrene might be sutured and turned into the gut lumen, by a Lembert stitch, as well as small punctures. If any considerable portion of the gut is gangrenous, it should be resected and the bowel restored by anastomosis. I would call attention to the idea of not invaginating the gut ends more than half an inch, as then the muscular contractions can beget no purchase power to continue the invaginations indefinitely until the artificial fistula formed by the anastomosis was closed mechanically by the apex of the invagination. I have had several experiences where the gut was at first invaginated about an inch to an inch and a half, but when the dog was killed, the apex of the invaginated gut had projected some three or four inches beyond the beginning and dropped into the artificial fistula like a wedge. The numerous important decisions which the operator is required to make under such complicated circumstances, tax all the powers of man. His decisions must stand the test of reason, and he must do the operation with such skill as to defy the criticism of

the best professional witness. Hesitation and mistakes weigh heavily against the patient's life, and justly doom the operator.

The foremost danger in all abdominal surgery is shock. Shock is simply injury to the peritoneum; the *modus operandi* of shock is through the sympathetic, cranial and spinal nerves. The effect is carried up to the medulla oblongata, and disturbs the automatic centers of circulation and respiration. The amount of shock, in general depends on the amount of injury done to the peritoneum and gut wall. The time which its abdominal cavity is exposed is also a prime factor. The intestinal surgeon should learn to operate with the greatest rapidity. Surprising manual dexterity can be acquired by operating on dogs for a few months; one of the main objects of superiority of modern over past intestinal surgery is, the rapidity of execution.

Anastomosis can be done in 15 minutes, while old circular enterorrhaphy at first required me to work over an hour. The next dreaded factor in the fearful triumvirate of physiological sequences is, peritonitis with its attendant vomiting and tympanitis. Pouring hot water into the abdominal cavity will lessen the shock and revive wonderfully the animal. A beginning peritonitis may be warded off by this procedure, and also by the aid of small oft-repeated doses of Rochelle or Epsom salt. The philosophy of this lies in flooding out the pathogenic microbes

per rectum, in producing intestinal contraction, and rendering the gut wall less permeable to germs.

Remarks may not be necessary, but I feel like protesting against indiscriminate, general laparotomy, by the tyro in surgery. This medical "taking off" by operation before the time, for fear a patient will die, seems to me an assumption of authority. I know of seven deaths not far distant, which occurred directly from the operation, either on the table, or very shortly after—all within a few months.

I have seen a tyro open the abdominal cavity, and then request some of the audience to direct what to do and to aid in the operation. Only the operator can escape death in such a procedure. No man should enter the abdominal cavity who has not carefully trained himself for the work. Laparotomy for intestinal obstruction is a much more serious matter than for abdominal tumor. The abdominal cavity and the alimentary canal are two different laboratories, requiring different methods of repair. One should understand the anatomy and relation of the viscera; he should have a knowledge of all the technique required for any operation that may arise. Complications will confront him, and contingencies suddenly appear which personal work alone will enable him to master. He should be able to do all kinds of operations, from the clipping of a ligament, to the resection and repair of a gut. Abdominal surgery is not a pioneer field any more, but is subject to distinct laws and methods,

accumulated by the experience of other workers in the past. The very fact that several operators have done fifty abdominal sections without a death, shows that law governs the matter. The only way to become an abdominal surgeon is by personal work. Knowledge and experiences are the combined forces. Much can be learned by attending the operations of noted specialists, by continually watching their methods, work, and patients. However, the essential knowledge and skill requisite must be acquired on the cadaver, and by experiments on living animals; the cadaver and living animal teach anatomy, structure, function, pathology, and repair—they impart knowledge. The skill and experience arise from the manual dexterity acquired in the work. The observation gained by personal application, and the responsibility of patients—even animals—sharpen both knowledge and experience. I know of four cases in the last two years that simply died from the operator's want of knowledge of technique. Laparotomy for intestinal obstruction is in its infancy, but it is the only rational method. It is natural, that in any great blessing to mankind, the first attempts should be partial failures. It was so in ovariotomy. It will be necessary, in laparotomy for intestinal obstruction, that some lives be sacrificed that future thousands may be saved. The time is not far distant when a surgeon will no longer stand by with folded hands, while a patient dies with bowel occlusion without laparotomy. Future pro-

gress in more definite clinical observations, will clear away the difficulties which at present surround the diagnosis; perfected technique will render the mortality beautifully less with the march of years. I collected 750 cases of laparotomy for intestinal obstruction. The average death rate was 65 per cent. It is no doubt higher than that, as the fatal cases did not all find their way into print, as men publish cases for some purpose, to show some method or principle, or to enhance reputation. I collected 613 cases of colotomy for intestinal obstruction, with a death rate of 40 per cent., but this left the patient with an artificial anus. The death rate would likely be as high as 65 per cent. by the time an operation had healed for restoring the canal and fæcal circulation. The main thing that keeps up a high rate of mortality in laparotomy for intestinal obstruction is, late diagnosis and faulty technique. The most reliable statistics which I could command made the fatality of intestinal laparotomy 58 per cent. in the last two years, a gain of 7 per cent. over previous years. The most prominent improvement in saving and prolonging life is from gastro-enterostomy. Much judgment and study will be required to know what to do with the gut when the obstruction has damaged. I lost a patient once by this lack of knowledge. She was an old lady, and quite feeble, who suffered from femoral hernia for 30 hours. I operated and found the gut discolored, but thought it healthy enough to recover. Also, the old

lady appeared as if she would die on the table with further operation. She rallied well; had copious stools for five days following the operation; on the fifth day the gut became perforated; and on the seventh she died from peritonitis. One must learn that a slightly discolored gut will gangrene. In invagination and volvulus the same keen judgment will be required, as both conditions will be found at times irreducible, and if gangrene has not occurred, they should be left in place. The intestine above the obstruction should be anastomosed to that below with rubber or rawhide plates.

I saw a noted surgeon, the other day, cut down in the groin to do Littre's operation for intestinal obstruction, when he was also compelled to make a median incision to remove a newly discovered tumor.

The Incision for laparotomy should be in the median line. It should be just as short as is compatible with the work to be done in the abdominal cavity. The accumulated experience of the past favors short incisions, and in the linea alba, as healing is most perfect. Hernia is not so likely to occur as in lateral incisions. The incision should be in the median, because it is almost always exploratory. No man can say just what is in the belly any more than he can tell what kind of wood lies under a table-cloth. Few would propose to diagnose a lead ball from a glass ball while lying concealed under a quilt. If one is convinced, of cœcal or sigmoid disease, a lateral inci-

sion is convenient. In all these operations the abdominal incision (98 per cent. in linea alba) healed from one to three times its original thickness. They were all closed by linen sutures, three to the inch, including skin, fascia, muscles, and peritoneum. Hernia occurred in about 3 per cent., but in every case it was shown in the autopsy that the sutures did not properly include that fascia or tendon which is the combined ending of the transverse and oblique muscles. The proper coaptation of the median fascia or tendon is the safeguard against hernia in man or any other animal. Every laparotomist should bear in mind that the object of operations, generally, is to repair and not to destroy. He, therefore, should carefully avoid sweeping removals of an organ that can be usefully saved. The removal of any abdominal organ not absolutely necessary, is a backward step in the art of surgery. It is detrimental to the even poise of animal life; it disturbs local functions, vasular currents; it incites unbalanced nerve forces, and deteriorates nutrition. The removal of a dog's testes or ovaries is followed by evcessive fat deposits, loss of nervous energy—laziness—and the organs of secretion and excretion are burdened and impaired.

Chloroform was used as an anæsthetic, and it killed about one dog in fifteen.

CHAPTER VII.

THE TECHNIQUE OF INTESTINAL SURGERY.

For thousands of years men have been attempting to apply a *technique* for the restoration of the fæcal circulation and the alimentary canal to a normal condition. Ages have come and gone with scarcely a sign of progress—not even a landmark to note the lapse of eras. There are no records to even suggest that Assyrians, Egyptians, Greeks, or Romans, ever employed any technique for restoring the intestinal canal or its circulation. The 12th century finds the London surgeons and the Paris masters introducing "elder pypes in the guttes under the seme that the seme rotte not." History records the use of cylinders of dried intestines, wax, bone, and tallow, to aid in uniting the wounds of the intestines. Ferrules of metal and the tracheas of animals were also employed, with wooden cylinders. All these substances were expected to be absorbed or passed by stool after the gut wound had healed; medical literature is simply a record of unobstructed deaths from intestinal obstruction through all past ages. Since the time that Wölfler, of Vienna, performed the first gastro-enterostomy in 1881, intestinal diagnosis and technique have sprung almost into a new branch, for both physician and surgeon to cultivate. The last decade has demonstrated from a reliable source that

circular enterorrhaphy is an unsafe operation even in the hands of the most expert. Hence arose the idea of anastomosis from the natural suggestions of bi-mucous fistula, artificial anus, and gastrostomy, all of which were compatible with life. The old operation for anastomosis was so appallingly fatal that the the boldest surgeons record but few. The fatality of the old operation depended, first on the length of time consumed, and second in the number of stitches required in the limited amount of functionally active tissue, often resulting in gangrene or fæcal fistula which invited peritonitis to end the scene. These results impelled man to seek new technique and methods. For anastomosis, the first improvement was the suggestion to produce fixation of the intestinal walls so that their serous surfaces would lie in apposition without much suturing. The idea came from Dr. Connell, of Milwaukee Hospital, Wisconsin, in the form of perforated discs or plates. This was successful, but it remained for that original genius, Dr. Nicholas Senn, to discover and place before the profession an absorbable perforated plate. Dr. Senn did this by well tested animal experimentation.

Three years ago I began a series of experiments on the intestines of animals with the object of testing what I could do with the healing of gut wounds. It was an inquiry and investigation into this field for the purpose of acquiring knowledge, skill, and dexterity, in abdominal work. At present writing the experi-

ments have consisted of over 175 operations of various kinds. I have given all the material I was acquainted with, a fair and faithful trial in anastomosis; every dog was carefully examined post mortem to observe results. The results of these 175 experiments have convinced me that the *raw hide* perforated plates, and the segmented *rubber plates*, which I originally introduced, are the safest, most suitable, cheap, and accessible, yet used in the work. Plates are generally better than rings, as they coapt a wider and more even serous surface for healing purposes, and especially produce fixation and consequently physiological rest.

1. *The Decalcified Perforated Bone Plates of Prof. Senn.*—The trial with these gave excellent results; absorption took place in from four to seven days. The nearer the stomach the anastomosis was done, the quicker the absorption of the discs occurred. Sometimes less than three days would absorb one in the stomach. These plates were sawn from the tibia of the ox (2½ x 9¼ inches). A diamond-shaped hole was cut in the centre (½ x ¾ inch). It required from 10 to 14 days to prepare them by the use of HCl. In drying, they will warp unless due care is exercised. The criticism due these plates is the time required to prepare them, the liability to warp, and the necessity of having various sizes to fit the gut under operation, as one can not cut them easily when well dried. A real objection against plates falls to the ground if one will

not dry them, but keep soft in alcohol; The warping will not then occur, and the disc can be cut to fit any gut. Also, the dried plate when placed in the intestine will swell, and its extra size might cause gangrene by this extra pressure. If kept in alcohol, most of the objections against the plates diminish, with the exception of preparation.

2. *Cat-gut Rings and Cat-gut Mats.*— Dr. Abbe, of New York, has suggested the use of cat-gut rings, and Dr. Davis, of Birmingham, Alabama, experimented with what he terms cat-gut mats. The modification is so slight that both of these means may be considered as one. The test with these methods gave good results in general, but the mat and ring do not beget that essential condition, fixation; and physiological and mechanical rest, further, they are apt to yield and absorb too soon, resulting in fæcal fistula. These means do not keep the bi-mucous or artificial fistula patent; it collapses, and the fæcal circulation is not allowed free action, to wear and keep it open by friction, and thus the opening will grow too small. The ring and mat can, however, be easily and rapidly made to fit any gut under operation. One objection against the mats is that they are apt to get hopelessly tangled. The real objections against mats and rings are that: (*a*) They do not give sufficient fixation: (*b*) They do not coapt enough serous surface: (*c*) They do not keep the bi-mucous fistula patent or wide enough during healing, and are also apt to absorb too

soon. The results after the use of catgut mats and rings, are that the newly made openings are too small and contracted. My experiments demonstrated, through the autopsies, that the contracted, stenosed, sphincter-like, bi-mucous or artificial fistula, would undoubtedly result in serious difficulty to the animal; that accidental mechanical abstructions would occur periodically from indigestion or imprudent eating. It must also be remembered that the seat of the anastomosis, in the majority of cases, will represent an impediment in the gut. It will be a jog, an unevenness, in the smooth bowel lumen, which will often demand more peristaltic force to drive the fæcal circulation continually through it. Experience teaches that artificial fistulæ tend to contract from one-fourth to three-fourths of their original size. For these simple reasons I discarded the use of catgut rings and catgut mats. It would appear from records, that Dr. Mates of New Orleans has some share of originality in suggesting the use of these means in intestinal anastomosis.

3. Dr. Brokaw of St. Louis, added another improvement to the technique of intestinal operations when he devised, and put to the test on animals, his segmented rubber rings held together by strands of catgut. I have used these in a large number of experiments with, generally, good results. I modified them by substituting for the dearer catgut the cheaper sheepskin (as found in shops) or strands of raw-hide.

The autopsies demonstrated that the thongs of sheepskin or raw-hide answered just as well, or better, as sheepskin strands are not quite so quickly absorbed. These segmented rubber rings are a good device for performing gastro-enterostomy, circular enterorraphy, and intestinal anastomosis. The gall bladder, or urinary bladder, can also be anastomosed to any point desired, with the rings. In my final experiments with these rings I found the best results came from the following method:

Take the softest quarter-inch rubber tubing, three and a half inches long, and cut it into six equal segments or pieces. It should be all rubber, so as to be soft, pliant, and yielding, presenting no little stiff prominences at the joints to slough through the gut Now, string these six pieces of rubber tubing on some four strands of cat-gut, or two strands of sheepskin or rawhide, and draw the strands until the points of the rubber tubing meet, when the ring is ready to be armed with six needles attached to six sutures. The sutures are attached to the strands between each rubber segment. These rings can be readily formed and enable one to do rapid operations, and they give fairly firm fixation after being tied together. They also keep the bi-mucous fistula fairly open and patent by their expanded condition when tied together. However, there is a tendency with the rings to allow too much collapsing of the bowel walls, and consequent stenosing of the bi-mucous fistula. The rings insure

tolerably good security with an omental graft. The criticism which I offer on these rings, after a crucial trial, is: (*a*) They are apt to slough the gut at the points of the rubber segment and produce fæcal fistula: (*b*) They do not coapt enough serous surface and hold it in approximation. Autopsies showed the healing took place exactly in circular form, corresponding to the coaptation of the rings. The serous gut surface healed only when distinct approximation occurred. Adhesions took place also, but that is a totally different thing from healing. The strength of the adhesions and the healing, lessened with distance from the immediate sides of the ring. The most serious fault found in the actual experiments with the ring was, that quite a number of dogs died from fæcal fistula occurring at the joints of the rubber segments. Two elements arise to cause this fistula: (*a*) The continual elastic pressure of the end of the rubber segment makes a hole in the gut wall: (*b*) The tightness of the sutures. Experience taught me that most of it was due to stiff rubber tubing, hence the rubber tubing should be absolutely soft, pliant, and yielding, and yet stiff or strong enough to maintain its own cylinder or column without a kink in any segment. Experience alone will enable a surgeon to properly tie a suture.

The rings are quite useful, convenient, shut easily, and rapidly made. They are valuable in internal work, and Dr. Brokaw should be congratulated on his device, for it has a future.

4. I will now present my own experience with technique, and also I am now able to place before the profession two new plates, well tested by animal experimentation. One is the *raw hide plate* and the other is the *segmented rubber plate.* For a long time I was looking for some plate more convenient and accessible than Dr. Senn's bone plate, which requires almost two weeks to make.

In 1889, I began experimenting with cartilage from the scapula of a steer. My attention was called to this by passing the butcher-shop daily and noticing that part of the scapula was cartilaginous. At that time I had never known it to have been used for anastamosis. I abandoned cartilage plates as they absorbed too quickly, and the dogs died of fæcal fistula. I then tried sole-leather, which was abandoned because it was not properly absorbable. I then began, in 1889, with the use of raw-hide in various forms.

I tried belt-leather by heating it between two pieces of tin, to drive out the resins, oils, etc. This I gave up, as it absorbed too soon. I then tried raw belt-leather with little tannin in it. This proved a success in nearly every case. Finally I began using green raw-hide with the hair shaved off. This proved to be a remarkably adaptable material, accessible, cheap, convenient, and the ideal of absorbability. The green raw-hide was prepared by shaving off the hair, drying it, and cutting the pieces 2½ x 1 inch. A dia-

mond-shaped hole was cut ¾ x ½ inch, and 6 awl holes bored in the plate, one at each end and two on each side. The plates were then threaded by three sutures and six round needles. The drying shrinks and thickens the hide, making it more stiff, which enhances fixation. The plates can be cut to suit the gut under operation; experiment taught that six sutures armed with six needles did safer and better work than a plate with only four sutures. Dr. Senn's original plate had four sutures and only the lateral were armed with needles. The intestinal anastomosis from these raw-hide plates showed excellent results; the union of the serous surface is firm and broad; the plates press uniformly and evenly in all directions, and there are no joints to gangrene the gut wall. They can be made long, extending beyond the anastomosis, thus giving the greatest possible fixation while healing. Stiff, hard, thick raw-hide will give all necessary fixation to heal. Raw-hide plates will absorb in from two to eight days, mainly depending on the position occupied in the alimentary tract. A raw-hide plate to be used in the stomach should be thickened by drying. I have repeatedly used raw-hide belt leather with little tannin in it, and good results followed. But the raw-hide with the hair shaved off gives most excellent results; when raw-hide plates are used for anastomosis, and the whole covered by an omental graft, the wound is as safe as any other wound. A large number of carefully con-

ducted experiments, with equally careful autopsies, has convinced me that a plate should be made of such material that it will keep the serous surface of the walls of the gut coapted for four or five days, before dissolution or absorption causes it to cease its pressure; when the dried, stiff raw-hide if introduced into the gut, will swell a little in a few hours, and thus tighten the coaptation. The serous gut surface being scarified, and the omental graft scarified, well applied, and fixed in position by sutures passing through the mesentery, a reliable result can be expected; occasionally a few over and under stitches may be added to strengthen the coaptation and prevent lateral leakage.

5. The segmented rubber plate is the latest product of intestinal technique which I have made and used. This is the ideal plate for the work. It is a plate which can be built up to remain intact as long as is desired; it can be made to be absorbed in one day or ten days. It is so ideal in absorbability that one can even make them to suit the activity of the alimentary secretions in any part. A particular characteristic of this segmented rubber plate is, that it gives perfect, uniform, even pressure, and constant coaptation as long as it lasts. No parts dissolve away to jeopardize weak or dangerous points. It is cheap, accessible, convenient to make, and easy to use.

It is scientifically absorbable; it gives uniform elastic constant pressure; it coapts the largest possible

serous surface, and; accurately maintains the approximation. It produces perfect fixation and all the mechanical and physiological rest required. No unyielding point projects to slough a gangrenous hole in the gut wall; and no strangulation will arise from swelling of the plates after insertion. It can be easily cut to fit any gut under operation. The plate is small and thin, and does not obstruct the gut lumen by bulk, but allows perfect fæcal circulation. I now use it exclusively, in preference to any and every other means of intestinal anastomosis. The segmented rubber plate is made by taking two pieces of rubber band, each 2 inches long and ¾-inch wide; cut out a triangular piece from each on the side for an aperture for fæcal circulation; now cut two holes in the side of each band and one at each end; stitch the two bands together at the ends with catgut, so that the end hole in each band will coincide. Now make a catgut, sheepskin, or raw-hide, ring, an inch in diameter, and attach to the ring six sutures armed with six round sewing needles. Then drop the needles through the holes in the rubber bands. The ring should be sewed to the plate by catgut stitches at each side for convenience. It will be seen that this rubber plate is entirely held together by catgut. The quantity, quality, and character of the ring (catgut, sheepskin, or raw-hide) will tell the story of absorption or life of the plate. Rapid operation, skilled execution, and excellent results, constitutes the utility of the segmented rubber plate. (See Appendix.)

CHAPTER VIII.

OMENTAL GRAFTING.

In experiments on the abdominal cavity of animals, the autopsies generally instruct more than the operation itself. At this writing, I have performed about 175 operative experiments on this cavity; most operations and results center themselves about the peritoneum. No surgeon can be too highly impressed with the significant power of the peritoneum, nor can its importance in the animal economy be over estimated. The peritoneum is a great lymph sac; it is a kind of a mediator or moderator between the external and internal economy. It stands on guard with constant vigil, always on the defense as to what shall enter its portals, and is an organ with vast powers, but with exceedingly delicate and dangerous susceptibilities. It is at one time the sole preserver of life, by the use of its barriers to imprison infection and protect against invasion, and at another the sole destroyer by receiving the enemy of existence — infection. Could peritonitis, the destructive element in abdominal surgery, be removed, the organs could be repaired with the certainty of arithmetic.

Two distinct ideas called my attention to the subject of grafting; one was deaths from leakage into the abdominal cavity, the other firm adhes-

ions found at autopsies. The next step was to know how to produce adhesions artificially, and the final work was to make adhesions protect the weak joints where danger lurked.

A distinct difference must be made between adhesion and healing. Adhesion is simply the cementing together of two parts by a plastic exudate of lymph, while healing not only includes the plastic exudate, but also a new formation of tissue—cells, vessels, nerves.

I had repeatedly observed the process and stages of the adhesions and healings in numerous autopsies for three years. I often found in the autopsy that a fold of omentum would fall against the operated part and adhere, covering up the wound so that it was effectually sealed. So I began to apply folds of omentum over the wounds without severing it from the peritoneum. This afforded excellent protection against leakage; but I noticed that the omentum adhered only where there was a wound or injury. Now, Prof. Senn had suggested in an article, to scarify the surface. This was employed with excellent results.

The idea of using an omental graft unsevered from the peritoneum could be condemned on proper ground. It might act as a band to strangulate the intestine, or drag on the gut and thus flex it, acutely causing obstruction. Hence the safest way to apply omental grafts is to sever entirely from the omentum,

then scarify the serous surface of the bowel, and also scarify one side of the graft, and coapt the two scarified parts. The graft should be held in position by a few fine sutures passed into the mesentery where there are few blood vessels. The graft should be large enough to pass entirely around the bowel and extend on to the mesentery. I found that a scarified graft adhered more quickly and strongly to a scarified mesentery than it would to a scarified intestine. I first scarified with the point of the scalpel, but found that scarifying with the point of a needle, lengthwise and crosswise like a checker board, procured better healing. I do not remember to have seen a single failure to heal in some 80 experiments where the graft was scarified on one side, and the surface of the gut and mesentery being also scarified and the graft sutured in position. Even if the dog died in less than a day the scarified parts had formed adhesions. Thorough superficial scarification is the essential ground for rapid adhesions and certain healing.

It was not uncommon to find in autopsies that a plastic exudate had saved the animal from death. Now when there is added to this plastic exudate a graft, composed of four layers of peritoneum (omentum), assurance is made doubly sure. I preferred to tear the grafts from the omentum rather than to cut them; in this way bleeding checked itself, as tying omental vessels often left a hæmatoma, or blood tumor, of

varying size. These grafts should be applied to intestinal wounds or any raw abdominal surface, stumps of tumors, etc., almost without exception. They should be large enough to well cover the wound. For a circular enterorrhaphy I generally tore them from the omentum two inches wide and long enough to completely encircle the bowel and extend on to the mesentery. For anastomosis they can be bigger. However if the surface is quite large it would be safer to apply more than one graft.

This idea of grafting, revived by Prof. Senn, with the addition of scarification, is a great advance in intestinal surgery. The scarified grafts adhere firmly in a few hours, but increase in the strength of the adhesions for about two weeks, and probably longer. The following case will illustrate the methods of application and growth.

Experiment No. 65.—Dog, male; weight, 12 pounds. Animal chloroformed, abdomen shaved, and intestine (small) with omentum drawn out of median incision.

1. A graft of omentum (severed) was applied around a scarified gut, and sutured in position.

2. An omental graft (severed), scarified, was applied around an unscarified gut, and sutured in position.

3. An omental graft (severed), scarified, was applied around a scarified gut and mesentery, and sutured in position.

4. An omental graft (severed), unscarified, was applied around an unscarified gut and mesentery, and sutured in position.

5. An omental graft (unsevered), unscarified, was applied to an unscarified gut, and sutured in position.

The grafts were about five inches long, and between two and three inches wide, and four were torn from the omentum. The fifth was left undisturbed at its proximal extremity. The omentum bled profusely, and was ligated. The bleeding was checked soon after by irrigating the abdominal cavity with hot water. Abdomen closed. Dog killed 48 hours after.

Graft No. 1 was pretty well grown to gut, but more strongly to mesentery. It had rolled up a little on the convex border of the intestine, and consolidated into a thick band of exudate. It was firmly adherent to side of gut and mesentery.

Graft No. 2 did not grow so adherent to gut. It was loosely attached to convex border of bowel. It was firmly adherent to mesentery.

Graft No. 3 was in excellent condition. It was solidly and firmly adherent to bowel and mesentery, so much so that the omentum itself would tear before the adhesions would separate. Scarification of graft, bowel, and mesentery, with fixation sutures, gives the highest perfection in grafting. A wonderful amount of repair had been done in this location in two days.

Graft No. 4 was but slightly attached to gut or mesentery. However, sufficient adhesions existed to sustain life in the graft, and would likely progress.

Graft No. 5 was but very slightly attached to convex surface of bowel, and firmly adherent to mesentery where it was sutured.

These same experiments are scattered throughout the cases, and can be noticed by reading the conditions of the autopsies, after the operations, from one to eighty days. I have, so far, seen no graft lose its vitality. The grafts were not severed until needed for use. They curl and roll up very often, and it is with difficulty they are separated; to avoid this, one can suture them in position before severing their proximal extremity. I used linen thread to suture them in position. The scarification should be done just deep enough to create a slight oozing.

CHAPTER IX.

CIRCULAR ENTORORRHAPHY.

This operation has been continued in one of two forms for the three years of experiment. It was done either with Czernay-Lembert or the continuous suture. The method of doing the operation generally rests on the kind of suture used. The past literature describes between 30 and 40 different kinds of sutures. Gussenbauer, Halstead, Bischoff and Dupuytren, have given good sutures. But I have confined the work to mainly two kinds of sutures, viz.; the Czernay-Lembert, and some to the continuous. The Czernay stitch is one where the edges of the bowel are simply sewed together by a continuous or interrupted suture, the needle penetrating the whole gut wall, mucous membrane, muscles and serous coat. The Lembert suture is one in which the needle passes through the serous coat and muscular layers only, but does not penetrate the mucous membrane. It simply applies "serosa against serosa." As the dog has a thick and strong aponeurosis in his bowel wall, it is capable of being practically done. The stitch in intestinal work is Lembert's. It is an interrupted stitch. The continuous stitch is good to strengthen coaptations and unite short rents. The objection against it is: It will loosen and allow the parts to separate, by one of the stitches giving way, or by contraction and

dilitation of the sutural parts. A third danger arises in actual work when the inside sutures slough into the gut lumen, and would be very liable to create a fæcal fistula with a thread partly within the gut and partly in the peritoneum. I would present the following arguments against circular enterorrhaphy, as viewed from experimental work:

1. It paralyzes, more or less, the segment of the gut by lessening the peristalsis. Thus the great object of the operation, which is the immediate relief of the obstruction, is lost. A paralyzed segment of gut is just as much an object of obstruction as a gall stone, an enterolith, or a volvulus. This may be seen in almost any case of peritonitis, and still more so in the autopsy, where many segments of bowel are over-distended, with normal conditions of permeability between. There is no stricture or occlusion in the intestine. These over-distended segments of bowel are paralyzed, and hence cannot propel the gases onward. Thus arises tympanitis. The peripheral nerves ending in gut wall and peritoneum are injured, and will not act.

2. Circular stricture will follow, and did actually occur in the experiments, narrowing to one-fourth or one-third of the original size. The dog, or any other animal, may live under such conditions, but is liable at any moment to complete obstruction from mechanical accidents.

3. The gut lumen may be very different in

size, and therefore difficult to safely unite; one could cut the gut ends oblique, but that would only make a larger operation, and more liable to be followed by a kink. Also one of the gut ends could be narrowed according to Billroth and Czernay, but it only adds to the danger of operation.

4. The essential condition in the operation is time, which is generally 45 minutes to one hour, using 25 to 40 Czernay-Lembert sutures. An hour of work on exposed intestine is often pregnant with shock. It hastens death and lessens resistance to disease.

5. Circular enterorrhaphy with a continuous suture, only, I think, should be condemned. It places the subject in a present danger, and also a future danger, much greater than anastomosis or Jobert's operation. More claim can be cited in its favor if the continuous suture is put in after a Czernay stitch has been used. Perforation and circular stricture are the dangers.

6. Fæcal fistula is apt to follow from gangrene of the gut tissue caused by numerous sutures. This does not require much demonstration to show its dangers; when a surgeon penetrates a bowel wall 30 to 40 times, it is no wonder that he should pass the needle a little too deep and make a fæcal fistula. He is also apt to affect the blood supply to the parts by the numerous sutures, and thus cut off nourishment. Again, in many obstructions, the bowel wall has become thinned by dilatation and with impaired func-

tions is apt to enhance the danger of perforation. An idea must be borne in mind that one side of the wound is distinctly and actively in a constant septic condition, and therefore the wound must be firmly united to successfully repel a constantly active, destructive agent.

7. The bowel is in a pathological condition due to injuries from the obstruction. The three essential elements, nerve periphery, circulation, and nutrition, are impaired in vital functions, and hence lessened in healing and resisting capacity. It is true we scarify the serous surface of the intestine to enhance healing, not, however, to the degree of impairing vital functions and parts, but simply to hasten repair by a plastic exudate. Some authors state that a pathological gut surface will unite better than a normal surface. It, of course, depends on the extent of the pathology.

8. A special danger arises in circular enterorrhaphy from a portion of intestine being uncovered by mesentery. It is not always easy or certain to stitch the mesentery over this part so as to nourish it. But it should be carefully watched that the adjacent peritoneum is snugly sutured to that portion of bowel either denuded by the operation or originally uncovered by peritoneum.

For the above practical reasons, circular enterorrhaphy should be discarded with its time-consuming process for the safer method of anastomosis which

can be done in one-third of the time. There is no doubt that anastomosis will supersede most other operations of its kind in intestinal surgery. When the gut lumen is large enough, Jobert's operation is superior to circular enterorrhaphy.

Experiment No. 110.—Circular enterorrhaphy. Dog; weight, 40 lbs. Abdomen opened, and loop of small intestine drawn out and completely severed, and then united by the Czernay-Lembert suture, using silk. Abdomen closed by three sutures to inch, including skin, muscles, fascia, and peritoneum. The dog was slightly sick a few days, after which he ate, drank, and played. Twenty-three days after, a second circular enterorrhaphy was performed on him. He struggled desperately. The gut was severed and reunited by Czernay-Lembert method. Dog did well until the next day at noon, when he was taken suddenly sick, apparently after a fight. The *autopsy* showed death had occurred from rupture of the old wound of 24 days previous. It appeared that in the struggle of the day before, the main exudate and adhesions had broken up, and that on the second day, at another fight, the remaining adhesions and stitches had broken loose; thus he died in 12 hours from intestino-peritoneal septicæmia. The new circular enterorrhaphy was healing nicely, and in 36 hours had bathed almost the whole united edges and sutures in a fibrinous exudate. No grafts were employed in either operation. The lumen of the bowel

was not contracted more than one-fourth its original size; one-fifth would probably represent it better. The dog was fed on soft foods.

Experiment No. 111.—Bitch; weight, 35 lbs. Animal chloroformed and loop of small intestine drawn out of abdominal median incision, and severed all but one-eighth of the circumference. The gut was reunited by Czernay-Lembert method (silk suture). She recovered without any bad symptoms; was slightly sick three days. Nine months after was delivered of a litter of puppies. One year after I again performed circular enterorrhaphy, by opening the abdomen and severing the gut, and reuniting it by a Czernay-Lembert suture; no grafts. She recovered well. I did not find the location of the old operation. The creature ate and drank well, and did not lose but very little flesh. The last time I saw her was 18 months after the first, and six months after the second, operation, when she was fat and happy.

Experiment 112.—Dog (puppy); weight, 15 lbs. Out of a median incision a loop of small intestine was drawn and severed, the divided gut ends united by a Czernay-Lembert stitch; no graft applied. He recovered almost without being sick, was given to a family to keep, and so far as I know is alive now (two years later).

Experiment No. 29. — Dog; weight, 30 lbs. Animal chloroformed, belly shaved, and loop of intestine drawn out of a median abdominal in-

cision. The gut was completely severed, and re-united with a *continuous* suture; the stitch was continuous from beginning to end. The edges of the gut were first united with a continuous Czernay's suture, then with the same unbroken thread a continuous Lembert's suture was formed, and; finally, with the same unbroken thread an omental graft was stitched firmly over the operated parts. The dog died twenty-four days after. from an operation for invagination. The *autopsy* showed the gut had lost two-thirds of its lumen; it was only one-third of its original size. The parts were firmly healed. Considerable cicatrical tissue existed in the bowel wall.

Would the circular stricture dilate, contract, or remain stationary? A cicatrix is often persistent and progressively contractile. Absorption or dilatation might occur. A dog, or man, could, no doubt, live with a gut lumen of one-third its original calibre, but accidental mechanical obstruction is liable to occur at any moment from non-digestible food, foreign bodies, and enteroliths.

Experiment No. 34. — Dog; weight, 9 lbs. Belly shaved and loop drawn out of medium incision and severed. It was re-united by a continuous Czerney's suture, and, with the same unbroken thread, a continuous Lembert's suture was carried out. It appeared that the gut lumen would be almost closed. Graft of omentum applied and held in position by four fixation sutures. The dog was

killed seventeen days after. The circular enterorrhaphy was well healed. The bowel lumen had contracted to one-fourth of its original size. The gut was three to four times as large above the stricture as below. The gut had dilated from obstruction. Considerable gas existed above the operated part and escaped on opening the gut. The gut on the proximal side was dilated, congested, and dark in color. It showed that the gut lumen, narrowed three-fourths or more of its calibre, had been dilated from the beginning. It was liable at any moment to complete obstruction from mechanical accidents.

Experiment No. 50.—Dog; weight, 12 lbs. A loop of intestine was drawn out of the abdomen, and two-thirds of the circumference of the gut was severed, when it was reunited with a continuous suture, that appeared to narrow the gut lumen about two-thirds of its calibre; finally it was well covered with omentum, and stitched to the mesentery. The animal was killed nine days after, and the wound found well and firmly healed. There were more fæces immediately above the operated parts than immediately below. Congestion existed in the proximal bowel, but not in the distal. The bowel lumen was contracted a little more than one-half, and its canal was tortuous. About ten inches of the thread used in the continuous suture, was found at the autopsy, lying in the bowel lumen. This thread might act as a source of danger in carrying infection into the peritoneal

cavity. Whether such cicatricial tissue would contract or dilate, time alone could tell. It is probable that accidental mechanical obstruction would occur in after years in such animals, and kill them.

REMARKS.—Many more of the same kind of experiments could be added, but these represent the types of the operation from the two kinds of sutures, viz., Czerny's and Lembert's sutures, and the continuous suture. My opinion is, that circular enterorrhaphy is at best an unsafe operation, and especially when done with a continuous suture. The recorded experiments show that each operation done with a continuous stitch is followed by a circular stricture narrowing the bowel lumen to one-third, one-fourth, and one-half its original size, and even producing pathological conditions with the first few weeks

A good lesson is learned from experiment No. 110, when, by a struggle, the dog ruptured an operation which had been growing well for 23 days. It declares the need of omental grafts and mechanical rest. In circular enterorrhaphy, so much serous surface is coapted for safety, that stricture is apt to follow. In some of the operations done with the continuous suture, I coapted more serous surface than was actually necessary, but it was done experimentally. I think the continuous suture should be mainly used as an extra suture to strengthen; it is very valuable, especially in short rents, and has the merit of being quickly applied.

An intestinal suture should not only have the merit of being quickly applied, but should be pliant, soft and not very large; it must be capable of keeping the serous surfaces securely coapted, as such eternal vigilance is the exact price of life. The suture material must not be irritating, and its time of absorption must be known. It must not be tied too tight nor even too loose. No suture should pass through the mucous membrane and peritoneum without having a special guard, as the plates and rings give it. Experiments have demonstrated to me that catgut is an unreliable and unsafe material for intestinal sutures, as it absorbs too quickly, and is clumsy. It does excellent work in some conditions.

I used in almost all of the experiments, Barbour's linen thread, No. 60, soaked in alcohol. It was absorbed, encapsulated, or sloughed out. Some silk was used; I would suggest that the pure English silk would be the ideal material, as it is of animal origin, and hence will finally disappear by absorption. It may be stated that in healing of a gut wall, the mucous membrane can be viewed as of no value, but may act as a plug to fill gaps and form a barrier to prevent leakage and preserve sutures from infection.

Dr. Matas, of New Orleans, has given the profession a valuable improvement in his catgut ring. It is excellent for the performance of circular enterorrhaphy. It is done in the same manner that Dr. Brokaw performed the operation of uniting divided

ends of bowels; the rings made to fit the end of the gut under operation. A catgut ring armed with as many sutures and needles as are required (4 to 6), is inserted into the divided bowel end. The needles are then pushed from inside the bowel outward. The sutures are equal distance from each other, and about ¼ inch from the margin of the divided gut. The corresponding sutures are now tied, uniting the severed intestinal ends. Dr. Matas' improvement over Dr. Brokaw's, if it be an improvement, lies in the prepared catgut from which he makes the ring by boiling it. This destroys its hygroscopic power along with the inconvenient kinking and tangling. The boiled gut will harden like rubber, and when used it is bent into a ring of desired size, and the two ends held together by a small piece of rubber tubing.

CHAPTER X.

THE CŒCUM AND VERMIFORM APPENDIX.

As only man, the higher apes, and the wombat, are possessed of a vermiform appendix, I was obliged to limit the experiments to the tapering cœcum of dogs, which, however, resembles man's appendix. The cœcum and appendix are important elements in intestinal surgery. This supposed remains of an ancient receptacle for food or fæces, is from a standpoint of evolution, fast fading out of existence. But since it is apt to remain to trouble the sons and daughters of Israel for a few generations yet, it is wise to seize the bull by the only horn of the dilemma presentable, and examine into the matter of its pathology thoroughly. Radical anatomical ground is the basis on which must rest the pathological views. All the cœca which I have examined, have been covered by peritoneum on all sides. Dr. Treves, after examining 100 fresh bodies, says, that in every case the cœcum was covered on all sides by peritoneum, and that the average measurement from the tip of the cœcum to the point where the peritoneum was reflected from the posterior surface of the ascending colon, was four inches. Now most anatomists agree that the cœcum will measure $3 \times 3 \times 2\frac{1}{2}$ inches; thus it is seen that no part of the cœcum is left uncovered peritoneum. In animals below man, a large part of by

the ascending colon is entirely covered by peritoneum, and swings, free from meso-colon, in the abdominal cavity. In this depression, external to the peritoneum, will lie the cœcum and its appendix. If this anatomy is accepted—and it is based on natural facts—much less time will be wasted on what is called typhilitis and peri-typhilitis.

Surgeons will then accept without quibble that the whole matter is simply appendicitis. It is a source of considerable mortality heretofore unsuspected by the general physician. At present surgeons recognize, that inflammation and perforation of the vermiform appendix by fæcal concretions or foreign bodies, is not an unfrequent cause of local or general peritonitis, resulting in death. The appendix vermiformis may have a mesentery or not. It originally had one, always, but evolutionary changes in growth may displace it until it lies against and parallel to the back of the cœcum.

Many lives are now being saved by extirpation of the appendix. The operation is indicated from repeated attacks of pain in the cœcal region, or in short when appendicitis can be diagnosed. The appendix can be removed at the height of inflammatory attacks or in the intervals of repose. The operator should practice removing the appendix in dogs, and in the cadaver, before he attempts it on man; as it is often attended with difficulties and complications, considerable practice is required to do it well.

Experiment No. 15. — Bitch; weight, 20 lbs. The animal had undergone an operation for extirpation of the spleen a month previous. The belly was shaved, and an incision was made from edge of right rectus muscle, 1½ inches from anterior superior spine of ilium along Poupart's ligament. The deep epigastric was severed, and bled freely. The oblique muscles were then recognized and divided, along with the tranversalis. The difficulty after entering the abdominal cavity lies in finding the appendix and recognizing its relations. The cœcum was stripped of its peritoneal folds, and 1½ inches amputated. The gut was then scarified, invaginated half an inch, and sutured with a Lembert's stitch until closed. No peritoneal graft was applied. The dog's cœcum contains two arteries from the ileo-colic running along its anterior and posterior surface, and in amputating, these were cut and bled vigorously. Linen thread was used. The *autopsy* five weeks afterward, showed the wound well healed; it had contracted into a stump rising to the level of the entrance of the ilium; the stitches were all absorbed. The whole wound had healed safe and secure. The scars and adhesions were few, and gradually disappearing The operation scarcely disturbed the creature, as she ate well on the third day. She died from a third operation.

The suggestions of the removal of the appendix first arose from Dr. Willard Parker; and his student, the celebrated Dr. Sands, operated with success sev-

eral times. At present, American surgeons who have developed the subject are divided in opinion as to the pathology. It is almost universally agreed that more than 95 per cent. of disease in the cœcal region arises from inflammation and perforation of the appendix. The primitive pathological action is, therefore, always outside of the peritoneum. The abscess will appear first in the mesentery of the appendix when it exists. If no mesentery exists, the abscess will perforate the peritoneum. An abscess in the mesentery of the appendix may extend between the wall of the cœcum and the peritoneum, and open into the areolar tissue behind the colon. Hence, we have from appendicitis, extra-peritoneal and intra-peritoneal abscess. Pathological anatomy would say that nearly all abscesses are intra-peritoneal. However, we do not know how many extra-peritoneal abscesses arise and recover. The suppurating centre lies at first external to the peritoneum. The symptoms of the disease are attacks, or repeated attacks, of pain in the right iliac fossa. Rise of temperature, chill, and vomiting, are frequent. The muscles over the seat of the disease are rigid and tender. All the cases which I have examined kept the right thigh flexed. A hardening or tumor can be felt in iliac region under an anæsthetic. One can nearly always perceive a pathognomonic symptom—viz., tenderness—by pressing the index finger over the location of the cœcum. This spot is about two inches from the anterior superior

spine toward the umbilicus. Pain may be general or local. The local or general peritonitis may cause local or general paralysis of the gut, resulting in distension and tympanitis. The exploring needle and the expectant plan of treatment should be abandoned. An operation should be done as soon as appendicitis is diagnosed, since fatal symptoms develop often suddenly and go swiftly onward and swiftly downward. Only a man trained in the work should attempt the operation. An incision should be made from a point 1½ inches from the anterior superior spine of the ilium toward the median line. It should be carried parallel to Poupart's ligament for at least 3 inches. The three abdominal muscles will then be recognized in division. Much difficulty may be experienced in finding and identifying the cœcum and its relations. No two cases are alike, and the appendix assumes all shapes, sizes, and conditions. Encysted abscesses may be encountered. The appendix may be sloughed off, and all kinds of pathology fill the scene.

The appendix should be ligated with catgut, silk, or linen, and amputated; its stump should be covered with peritoneum, and the wound drained and closed. The results of the last two years' operations for the removal of the appendix, have been the most gratifying of any surgical procedure yet introduced.

CHAPTER XI.

INTESTINAL ANASTOMOSIS.

This term suggests the opening of one mouth into another. Anastomosis denotes the uniting, communicating, or emptying, of one vessel into another, be it vein, artery, lymphatic, or bowel. By intestinal anastomosis is understood the communication of a bowel above a certain point (of obstruction) to the bowel below the same, by means of an artificial fistula. The bi-mucous or artificial fistula conducts the fæcal current through the new channel. By this method the obstruction is partially or totally relieved.

The idea of relieving an obstruction by means of a bi-mucous or artificial fistula, without making an artificial anus, arose with the French. But, as the first cases were fatal, the subject was killed for a time by the unreasonable opposition of medical men. The opposition of the French doctors against the operation of anastomosis was, the curious idea that the portion of excluded bowel would become the seat of accumulated fæces, and that in itself would be an obstruction which would finally be fatal. This was pure physiological ignorance which could be made positively known and clearly demonstrated by a few experiments on animals. The experiments which I have conducted on dogs, demonstrate that fæces will *not* accumulate in the excluded bowel; in fact it is

rare to find any fæces in the gut excluded by the artificial fistula. It appears that the fæcal current takes the shortest route and also the one of least resistance. I observed this subject carefully through every experiment, and now no doubt exists in my mind that the idea of fæcal accumulation in the excluded bowel is without foundation. Animal experimentation has forced objectors to give up the fæcal accumulation idea, and established anastomosis as a recognized surgical operation with an unlimited future. The first step of progress in modern intestinal anastomosis, consists in the employment of oval discs, as first suggested by my friend Dr. M. E. Connell, of Milwaukee Hospital. These discs coapt the serous surface of the bowel until it is healed. In the anastomotic experiments, I tried almost all kinds of material possessing any degree of suitability: Decalcified bone, cartilage, leather, sole- and belt-leather, catgut rings, segmented rubber rings, raw-hide and segmented rubber plates, all were employed for a long time, and all given crucial tests. The last two plates I can well recommend to the profession as excellent means to anastomose intestines. Plates are superior to rings on account of the coaptation of extensive serous surfaces. The raw hide and segmented rubber plates are convenient, accessible, easily and quickly made, suitably absorbable, coapt a large surface, press equably in all directions, cause no sloughing or gangrene, and produce fixation and consequent physiological rest.

At present I am inclined more to the segmented rubber plates as to cheapness, convenience, suitability and utility. I think they have a large future. The rubber plates are the product of a long experimental study in this subject, and that they will be useful in future work is the wish of their author. In the following experiments I have used the word *Ileo-ileostomy*, arbitrarily, to cover all anastomosis from duodenum to cœcum.

ILEO-ILEOSTOMY, WITH DECALCIFIED PERFORATED BONE-PLATE.

Experiment No. 1.—Dog; weight 12, lbs. Through a medium incision, a loop of intestine was drawn, and some fifteen inches excluded in the anastomosis. The gut was then incised an inch on the convex surface, and decalcified perforated bone plates, an inch wide, two and one-half long, and one-fourth thick, introduced into the gut lumen. The plates were armed with four sutures, having a needle on the two lateral sides only, and the needles (common sewing) pushed from within the gut outward through its whole thickness. (No. 60 Barbour's linen thread was used.) The incised intestines, with a plate in each, were now brought opposite each other, and the surfaces of the gut immediately over the plates scarified with point of the scalpel. The corresponding four threads of each plate were tied, and the incisions and plates accurately and closely approxi-

mated, and abdomen closed. Dog sick for four days, after which he ate and drank well.

Animal killed ten days after. Plates entirely gone. The anastomosis was perfectly healed and the fæcal current passed entirely through the artificial fistula, which was about the same size as the natural gut lumen. No fæces were found in excluded bowel loop.

Experiment No. 3.—Dog; weight, 20 lbs. Plates, fresh cartilage from scapula of steer, were introduced into incision on convex surface of the ilium, which was drawn out of a median abdominal incision. These plates were $2 \times 1 \times \frac{1}{4}$ inches, having four linen sutures, the two lateral each armed with a needle. The lateral needles were pushed from within the gut lumen out, piercing the whole gut-wall, about one-fourth of an inch from the margin of the incision. The plates, lying in the gut, were brought *vis-a-vis*, and the intestinal surfaces over the plates (peritoneal) scarified with point of scalpel. The lower lateral stitch was first tied, then the two end stitches, and finally the upper. A few over-stitches were applied. An unsevered omental graft was applied over the anastomosed parts and stitched in position. The recovery was excellent in every way. Dog killed fifteen days after. Plates entirely gone. The anastomosis healed, and fæcal circulation perfectly established. Omental flap solidly and firmly grown to parts, enclosing them almost hermetically.

No fæces was found in the excluded loop, and the color of the mucous membrane demonstrated that the fæcal circulation passed entirely through the new channel.

Experiment No. 5.—Dog; weight, 30 lbs. Raw hide plates (belt leather, with little tannin in it—also plates were placed between two pieces of tin and heated until the resinous material was driven out, which made the plates shrink). Dog chloroformed, and belly shaved; median incision; small intestine drawn out and three feet excluded. The plates, armed with four sutures and two lateral needles, were introduced into the lumen of the gut through an incision on convex border. The serous surfaces over the plates were scarified, the plates approximated, and the four sutures tied; omental graft applied and sutured in position. The operation lasted 30 minutes. Recovery was excellent. Dog killed seven days after, and the autopsy showed plates entirely gone. The anastomosis was well healed, and fæcal circulation perfectly established. Omental graft solidly and firmly adherent. Scarcely a sign of fæces found in the three feet of excluded ilium, and its color and contracted condition demonstrated its non-activity in fæcal circulation. The color of the mucous membrane of the excluded loop became redder as one proceeded from the anastomosis, showing its gradual elimination from use. Such excluded mucous membrane has shown in the experiments that

soon after exclusion it became hyperæmic, very red, then, as time progresses, gradually pales.

Experiment No. 7.—Dog; weight, 30 lbs. Operation: Ileo-colostomy, with raw hide plate ("tried out") on one side and, sole-leather plate on the other. The plates were introduced as usual—one, the raw hide, in ilium, and the sole-leather in the ascending colon. Scarification and approximation by sutures; omental graft applied and sutured in position. Temperature in the rectum on the third day, 102½° Dog died on fourth day from peritonitis. The autopsy showed the raw hide plate entirely absorbed, but the sole-leather plate was about the same as when introduced. The anastamosis was well healed, and fæcal circulation passed through the artificial fistula. The graft had grown firm and solid.

Experiment No. 13. — Dog; weight, 15 lbs. Operation: Ileo-ileostomy with sole-leather plates. Dog chloroformed, abdomen shaved, median incision, and ilium drawn out; about three feet of gut excluded. The plates were threaded with simply two sutures by passing the needle through the end awl-hole, and then re-passing the needle through the lateral awl-hole; this armed the lateral sutures only with needles; it also did away with the extra ring suture on the back of the plate, as employed by Prof. Senn. An incision was made on convex side of bowel, plates introduced into gut lumen, and the lateral needles pushed from within out. The intes-

tine was scarified, the plates approximated, and the four corresponding sutures tied, and the ends shoved in between the plates; an omental graft applied and sutured in position by four fine stitches. The dog was scarcely sick. He ate, drank, and played almost from the beginning. Finally escaped and wandered about the city, but was re-captured in forty days.

Dog chloroformed to death, forty-nine days after the operation. Abdominal organs looked healthy. The omental graft had grown firm, and made a ball adhesion around the anastomosis. The sole-leather plates were in just the same position and condition as at the time of operation; three of the sutures were yet intact, the fourth broken. Four ulcers existed, one as large as a nickel; some ulcerated quite deep into the mucous membrane. This settled the fact to me that sole-leather plates are totally unsuitable for intestinal anastomosis. A large collection of straw, hay, etc., had lodged against the plates, and dilated the artificial fistula to about three times its original size. A loop of intestine had firmly grown along the abdominal incision, which could have been avoided by re-spreading the omentum. It undoubtedly would be a future menance to the dog's life.

Experiment No. 4.—Dog; weight, 15 lbs. Operation: Ileo-ileostomy, with raw hide plates. The ilium incised and plates introduced, approximated and tied; parts scarified, and graft applied.. Linea alba incision closed. Time of operation, 20 minutes.

The dog killed himself five days after by tearing out the sutures and opening the whole abdominal cavity. Autopsy showed the plates entirely absorbed, and it would appear that they absorbed in less than 3½ days.

Experiment No. 2.—Dog; weight, 15 lbs. Operation: Ileo-ileostomy, with cartilage plates from scapula of steer. The ilium was drawn out of median incision, and plates introduced through incision on convex border of gut; the two lateral needles punctured the gut one-fourth of an inch from margin of incision; parts scarified, plates coapted, and sutures tied. Dog died in 36 hours from intestino-peritoneal septicæmia, due to leakage at the edge of the plates. It appears that the cartilage softened so quick, that it did not hold the coapted serous surfaces in contact for sufficient length of time to form adhesions. Silk was used, and 12 inches of gut was excluded in the anastomosis, some parts of which had formed firm adhesions. Cartilage absorbs too quickly, and four to five days coaptation is required to ensure security.

Experiment No. 22.— Bitch; weight, 15 lbs. Operation: Ileo-ileostomy, with raw hide plates. Dog chloroformed, belly shaved, medium incision two inches long, out of which was drawn the ilium, and 10 inches excluded by the anastomosis. The raw hide plates with four sutures of linen, and two needles, were introduced into the lumen of the gut through an incision three-fourths of an inch long on convex border of intestine. The serous surfaces around the

two gut incisions were scarified, the plates brought together, accurately coapted, and the corresponding four sutures tied and cut off short. A continuous over-suture was applied. Omental graft applied and fixed in position by four fine stitches. The surfaces and graft were generally scarified. The excluded ilium loop was thus completely secured, each end invaginated one inch, and closed with six continuous sutures. Good recovery; dog killed 15 days after. The invaginated ends were still further invaginated—about two inches each; the stitches were passed along with the continually invaginating bowel entirely out of sight. How long would such process continue? Experience in other cases showed five inches of sutured invaginated gut in nine days. The raw hide plates were entirely absorbed; graft well healed. The artificial fistula was larger. Dog lost about three pounds in weight. The abdominal cavity being open, a rubber balloon was filled with air and the dog given a rectal insufflation. The air was observed while it passed the whole alimentary canal to nose, out of which it escaped. The required pressure was small. The valve of Bauhin was easily overcome, as well as the pyloric sphincter, but this was owing to abdominal wall pressure being removed. Operation completed in twenty-five minutes.

Experiment No. 23.—Dog; weight, 15 lbs; old. Operation: Colo-colotomy, with raw hide plates from belt leather with some tannin in it. Dog

chloroformed, and as much colon drawn out as was convenient. The plates, armed as before, were introduced into incisions on convex surface some fifteen inches apart, thus excluding twelve inches of colon; scarification; plates coapted and tied. The excluded colon was kinked or flexed at as short and acute an angle as possible, and firmly stitched in position with three interrupted sutures on each side. Graft applied and fixed in position by sutures; operation lasted twenty-five minutes.

The dog was chloroformed to death in nine days. Abdominal organs were healthy except the bands formed by adhesions to omentum. Graft well grown to parts; the plates in colon not yet gone.—The belt leather had tannin in it, and the absorptive powers of the colon are very limited. The anastomosis was tested by forcing water from a faucet slowly through the stomach, and Bauhin's valve, to rectum. No leakage occurred at plates. The flexion and kink, which was fixed in position by three sutures on each side, had gradually wormed itself loose. It had so twisted itself out of the sutures and acute angle, as to be patent and allow a little fluid to pass. But almost the entire fæcal circulation passed through the artificial fistula. This dog was scarcely sick at all. It was instructive and interesting to see water pass from stomach to rectum, to watch the filling intestines twist and turn, loop and coil, contract and dilate. In each case the

three sphincters, (or three ani)—pylorus, ileo-colic valve, and rectum—had to be distinctly overcome.

Experiment No. 25. — Dog; weight 25 lbs. Operation: Ileo-ileostomy. Raw hide plates with a little tannin (belt leather).—A test on the alimentary canal's absorptive powers while suffering from dysentery. Dog anæsthetized; abdomen opened in median line and loop of small intestine drawn out. The plates armed with four sutures and two lateral needles, were inserted into an incision on the convex surface of the gut; the surfaces over the plates ($2\frac{1}{2} \times 1 \times \frac{1}{8}$ inch) scarified and coapted. The corresponding four sutures were then tied, excluding about a foot of the ilium by the anastomosis. The operation was completed in less than twenty minutes. The dog died sixteen days after from the same dysentery which it had at the time of the operation. The operation did not seem to influence the disease or dog. The animal passed blood at time of operation, and in exactly the same manner for the two following weeks. The autopsy demonstrated the whole intestinal canal with an inflamed mucous membrane—even to the bottom of the cœcum. Coarse and fine clots of blood were found from stomach to rectum, very uniformly distributed. The plates were not absorbed, but softened. I have observed that the power of the alimentary tract is seriously impaired in its ability to absorb any plate when suffering from (especially) any extensive acute disease, *e.g.*, peritonitis, septicæmia, catarrh,

diarrhœa, or dystentery. The whole peritoneal cavity looked absolutely healthy except some adhesive bands which had originated from a local inflammation around the anastomosis, and which had all subsided. The inflammation had caused two attachments to gut surfaces, and thus made two loops of bowel which might become sources of future danger; graft firmly and solidly grown to parts. All the viscera looked extremely pale from gradual and continuous loss of blood, and even the blood was pale and watery. The artificial passage was large enough to admit thumb, and the fæcal circulation almost if not entirely passing through artificial fistula. No ulcers were found at seat of plates. This was the most perfect example of an anastomosis hermetically sealed by an omental graft. It afforded absolute protection against leakage of intestinal contents. The plates would no doubt absorb with returning health of the bowel.

Experiment No. 27.—Dog; young animal; weight, 25 lbs. Operation: Ileo-ileostomy with six segmented rubber tube rings held together by four strands of catgut. (Brokaw's).

Dog chloroformed, belly shaved, and median incision made, through which was pulled a loop of small intestine, aud two incisions made on the convex border of the bowel wall most distant from the mesenteric attachment. Into each of these two incisions of the gut were inserted a segmented rubber ring armed with six sutures with ordinary sewing needles.

The needles were pushed from the lumen of the gut outward, penetrating its whole thickness. The same was done with the other incised bowel. The serous surface over the rings was then scarified, the plates approximated, and the six corresponding threads tied, the knots being buried by pushing them between the coapted gut walls. A severed omental graft was applied after three over sutures were inserted to make doubly sure. Now hot water was poured into the dog's belly, which at once served to arouse him from his shock; the water was about 110° F. Abdomen closed with three linen sutures to inch, including skin, muscles, fasciæ, and peritoneum (which method was used throughout the whole series of experiments). The animal recovered nicely, and was chloroformed to death 18 days after the operation. (In the meantime he had also undergone an operation for gastro-enterostomy.) The anastomosis had healed perfectly, but had contracted to ⅔ of its original size, only admitting the end of the little finger, which is too small for a dog of his weight. The reason for this was that the excluded ilium loop was only some six inches, and in no way obstructed, so that the main fæcal circulation passed by the old natural channel, and hence did not keep the artificial fistula open by wear and friction of the fæces. The severed peritoneal or omental graft had healed perfectly, sealing hermetically the anastomosed parts. Some omental adhesions existed,

showing the rise and fall of a local peritonitis. It is the safest for the future of the animal, to sever the peritoneal grafts, for though bands and adhesions are liable to arise with any operation, they are sure to arise with an unsevered graft, one at least being made at the time of operation. However, the experiments demonstrated that grafts grew much more certain when unsevered from omentum. The anastomosis, constituting the ileo-ileostomy, was located one foot from the valve of Bauhin. Even in this case of distinctly severed graft, and the use of hot water in the peritoneal cavity, after three weeks, was found three distinct omental bands, varying from 3 to 15 inches long, variously attached, forming treacherous arcades to catch and strangulate a wandering gut. Only two stitches were found in the wound. The rubber segment had disappeared. The rings were an inch in diameter.

Experiment No. 28.—Dog; weight 20 lbs. Operation: Ileo-ileostomy with catgut mats. (Davis'). The ilium was drawn through an abdominal median incision, and a loop anastomosed. Catgut mats were introduced through incisions on the convex border of the bowel, and the six sutures armed with six needles, pushed from within the gut outward. The serous gut-surface was then scarified, the mats accurately approximated by binding them *vis-a-vis*, and the corresponding six threads tied. The anastomosed parts were then scarified, and a severed

omental graft closely applied and stitched in position.—One can either sever the omental grafts and then suture them in position, or suture them first in position, and then sever them; in this case we did the latter. The abdominal cavity was well irrigated with hot water (110° F).

Dog chloroformed to death, sixteen days after operation, but in the meanwhile had undergone gastro-enterostomy—eight days previous. Abdominal cavity was healthy in appearance. The catgut mats entirely gone. The severed omental graft had grown so solidly and firmly that to tear it off simply ruptured the tissue. The anastomosis was extremely firm in its growth. The artificial fistula had contracted to one-third its original size. The reason of this lies in the fact that the catgut is not stiff or rigid enough to keep the fistula open or patent, but after the mat has been in the intestinal lumen a short time, it becomes soft and collapses. Not enough fixation is given by a catgut mat; the raw-hide or segmented rubber plate does it much better.

Experiment No. 35.—Dog; weight, 30 lbs. Operation: Ileo-ileostomy with segmented rubber rings, held together by catgut mats and armed with six sutures and six needles. The ilium was drawn through a medium incision, and the plates inserted into incisions on the convex border of the bowel; the needles were pushed through the gut wall, the serous surfaces scarified, and the rings coapted and corresponding

threads tied; no graft. Thirteen days after the dog was again operated on for invagination of the small intestine. The invagination became gangrenous and killed him in about 20 hours, but the anastomosis was firmly healed. The rings were not gone, as the double operation produced progressive marasmus, and in such cases the absorptive power of the alimentary is very much lessened. However, the fæcal circulation passed through the artificial fistula, and the rings would soon pass away. Steady, progresive, marasmus took place with this dog the first operation. The second operation, when following close on the first, often so shocks the system that marasmus occurs with wonderful rapidity. Dogs weighing 20 lbs. will occasionally loose a pound a day, and it was not infrequent for an ordinary size dog to loose a half pound daily steadily, and yet eat considerable at the same time.

Experiment No. 40.—Dog; weight, 12 lbs. Operation: Ileo-ileostomy with rawhide plates. The plates are prepared by taking a green hide and simply shaving off the hair, and drying them, when they are ready for use. Out of a two-inch medium incision, a loop of intestine was drawn, and rawhide plates inserted into incisions made on the convex border of the bowel. The convenience of the rawhide is, that the plates can be cut to fit the gut under operation. The serous surface of the bowel lying over the plates was scarified. Each plate was coapted to the other,

and the six sutures which penetrated the bowel wall tied to the corresponding six sutures on the other plate; no over or under sutures; omental graft applied and held in position by five sutures. The dog had an uninterrupted recovery. Nine days after he had a circular enterorrhaphy performed, and recovered excellently.

He was chloroformed to death 18 days after the first operation. The ileo-ileostomy was healed perfectly, and the graft grown fast. The artificial fistula was about the size of a thick lead-pencil, but was used considerable for the fæcal circulation. The linen sutures were still in the edges of the bi-mucous fistula, but the plates of rawhide were entirely absorbed. The dog had no untoward symptom, but steadily gained in health and strength.

Experiment No. 60.—Bitch; weight, 25 lbs. Operation: Ileo-ileostomy with exclusion of four and a half feet of ilium. Animal chloroformed, belly shaved, and two-inch incision made in linea alba. The index and middle finger introduced into abdomen pushed omentum to left and drew out a long loop of ilium. The gut was severed twice, five feet apart, and the ends invaginated an inch each, and closed with a continuous Lembert stitch. The proximal and distal bowel ends were then anastomosed by incising the convex border of the bowel and inserting the segmented rubber rings. The six needles attached to the rings were pushed through the gut wall; no

scarification; plates approximated and corresponding sutures tied; an unsevered omental graft applied. I manipulated the intestine so as to fill the excluded part quite full of fæces. The anastomosis occurred three inches from the ileo-cœcal valve. The dog recovered well, and ate and drank freely; she was chloroformed to death fourteen days after the operation. The abdominal cavity looked fairly healthy, but showed that a local peritonitis had arisen and subsided. The five feet of excluded gut were a little fuller at the autopsy than at the operation fourteen days previous, and the fæces had all liquified and turned into a green color, caused, no doubt, by the large increase of the green vegetable microbes. The secretions into the bowel had been slightly in excess of the absorption; however, I think this was a mere temporary irritation exciting the peripheral nerves to excessive action; it did not trouble the dog during life, from all appearances. The gut wall was slightly congested. A very important observation was made, viz.: That one end of the excluded gut was found invaginated five inches instead of one, which was done at the operation, and the other was found invaginated three inches instead of one. This is an important matter, for in an anastomosis the invagination might continue until it plugged the artificial bi-mucous fistula. Several experiences have occurred similar to this one. The artificial fistula would admit only the little finger. On the proximal side of the anastomosis had

collected an enterolith—two distinct masses or rolls of hay and straw. The enterolith had dilated the intestinal lumen to twice its natural size. It would never have passed through the artificial fistula without liquefying. The liquid food was continually trickling around and through it. In this case, also, was demonstrated the idea that the anastomosis should take place near the end of invaginated gut, as one of the masses passed beyond the artificial fistula and lodged in it as a pocket—like a foreign body in a cœcum or appendix. The rings were gone, except three of the rubber segments were found lodged in the enterolith. She played most of the second week.

Experiment No. 63.—Dog (species bull); weight, 50 lbs. Operation: Pylorectomy with raw-hide plates. After he was chloroformed, the abdomen was shaved, and the stomach drawn out of a median incision. A dog, unlike a man, has a meso-duodenum, and therefore the duodenum can be drawn further out than in man, but even then with great difficulty. The duodenum was severed, and the pylorus invaginated toward the stomach, the other end toward the perineum, and both closed with a continuous Lembert suture. The pendant portion of the stomach was then anastomosed to the lower remaining part of the duodenum by making an incision into the stomach and gut, and inserting the raw-hide plates, pushing the needles from the mucous membrane outward, then coapting the plates, serosa to serosa, and tying separately the

six corresponding threads; scarification; continuous suture applied between the serous surface of the stomach and the gut wall, at the point of approximation.

A point here requires to be mentioned: The incision on the serous and muscular wall of stomach was one and one-half inches long, which for a dog of forty to fifty pounds, generally heals with lumen large enough for functional and physiological purposes; but while incising the mucous membrane (which acts like a bag inside the stomach, apparently much too big and hence thrown into folds), a physician standing by said: "Doctor, have you not made that big enough?"—It was then one and one-fourth inches long, not quite as long as the muscular and serous incision. Thus it was left, but, in my opinion, not sufficient long, as the stomach was full when operated on, hence the deception of the amount and extent of mucous membrane.

The dog suffered considerable shock from dragging on stomach and deodenum, so hot water was poured into abdomen. It soon aroused him, and he rallied well. The pancreas was badly wounded in the operation.

Twenty-four hours after, the dog tore the sutures out of the abdomen, and for this reason was destroyed, as general peritonitis would certainly kill an animal with intestines thus exposed. The autopsy showed beginning peritonitis; omental graft had adhered firmly;

the anastomosis was doing well; the duodendal invagination was perfect; the pyloric invagination close to the pancreatic wound looked suspicious, as if a slight leak had occurred. But the instructive part of the matter was that the stomach was found quite distended. The cause was quickly found to be a prolapsed plug of mucous membrane, which filled the artificial fistula, and acted just like a valve; by drawing or moving the stomach, fluids trickled through. This experience evidences that this inner jacket, which is larger than the outer, must be incised as large or larger than the outer.

The raw-hide plate in the stomach was about gone, but the one in the duodenum was simply well softened. I think that the raw-hide plates for the stomach should be thick and well dried, so that too rapid absorption would not occur.

Experiment No. 76.—Bitch; weight 20 lbs. The animal was shot through abdomen, and having wounded no intestines, an anastomosis was done with the segmented rubber plates (ileo-ileostomy), 15 inches of ilium being excluded; scarification; a few over sutures were applied but no graft. The creature recovered nicely, and was operated on for gunshot wounds of the intestines 17 days after. The anastomosis was well healed, and plates gone. No peritoneal adhesions existed. The rubber plates acted excellently in this case.

The operations and experiments are self-explan-

atory. No. 13 shows that sole leather plates are totally unsuitable for the work; they will not absorb; the pressure creates ulceration, and the plates themselves cause obstruction. They would likely kill the dog unless they were passed per rectum, which is the more probable.

No. 2 shows that cartilage absorbs too soon, and killed this dog. This was my general experience with cartilage. It would appear from experiments, that a plate which does the best work should remain intact for five days, and keep the parts in coaptation. Proper pressure will form no ulceration in that time, and the threads will have a chance to become excluded from the peritoneal cavity by ulceration and exudates, so as to prevent infection along their tract.

Nos. 22 and 60 call attention to the idea that inflammation may go too far and do damage. This shows a gain of 2 to 4 inches of invagination after the operation. It should be avoided by invaginating ½ to 1 inch of gut, and then no peristaltis can get purchase power on so short a segment; the longitudinal muscles, which seem to be the element of power, are thus cut off.

No. 23 shows how sharp kinks will vigorously right themselves.

Nos. 27, 28, and 29, demonstrate that dogs will bear several operations on the peritoneum in a short time, but marasmus is liable to follow, even though the dog eats with a ravenous appetite.

No. 20 shows that a plate must have fixation, or the resulting artificial fistula may be too small. If the plate does not hold the fistula patent, it will collapse and grow together, and will also grow too small if fæces do not keep it open by constant circulation. Many more operations of this kind could be added, but these are sufficient to demonstrate the material used, methods of healing, and technique.

CHAPTER XII.

INTESTINAL INVAGINATION.

SYNONYMS— { INTUSSUSCEPTION. TELESCOPING.

As this subject constitutes the most significant and important part of intestinal surgery, it will be given a little more in detail. By intestinal invagination, is understood the sliding of a part of intestine into the lumen of that immediately adjacent to it. One part of the circumference of a gut is drawn over the circumference of a part adjoining it. It is the most common form of intestinal obstruction, and at the same time the most fatally destructive to life. The opportunities to study this subject on human patients, in any single locality, are very meager. Therefore, in order to study its clinical and pathological conditions, I produced it artificially on a series of dogs, and observed its effects during life, and finally in the autopsy. Artificial production of invagination is accomplished by opening the abdomen, seizing the bowel between the finger and thumb of the left hand, while the right hand indents the gut wall with a pair of blunt forceps and pushes the pouch slowly into the adjoining intestinal lumen. The main difficulty lies in getting the invagination started; but if one waits until the first peristaltic wave has passed,

the formation of an intussusception easily follows and it glides onward like a fæcal mass until checked mechanically. The essential check is the mesentery. The invagination in a large majority of cases will dis-invaginate itself in from a few minutes to several days. Dis-invagination was so vigorous in healthy dogs, that I was compelled to suture the invagination n position with from one to six sutures inserted into the gut wall and mesentery at the neck of the invagination. This failed in most cases, and the dis-invagination was so active that it tore the sutures out, making fæcal fistulæ from which some animals died. In the autopsies, it could be observed that the gut had dis-invaginated by twisting and insinuating itself between sutures, leaving the intestine with a much narrowed lumen. Some reduced themselves on the fourth day, leaving the apex and neck gangrenous in appearance. Both parts looked dark, and the neck was much constricted. The parts were considerably paralyzed, but would respond slightly to irritation. It was often apparent when dis-invagination had occurred, as the dog became easy and showed a condition free from distress. The effect of invagination on dogs is very disastrous. It produces a profound impression on the whole organism, and especially upon the nervous system; it makes a distinct shock from which the animal slowly recovers. The invagination does not produce complete bowel occlusion, and hence the pain is intermittent. The dog often stands

with his four limbs well separated, back arched, and at times shows symptoms of pain. Tenesmus is an early symptom, and blood and mucous will appear often in the stool. Vomiting is sometimes present, but is not conspicuous. The clinical experiments will be inserted in different parts of the chapter.

Experiment No. 57.—Dog; weight, 25 lbs. Operation: Invagination with intestinal anastomosis, excluding the invagination. The animal was chloroformed, the abdomen shaved, and a median incision made. The omentum was pushed to the left and a loop of small intestine drawn out and invaginated 6 inches, but which contracted to $4\frac{1}{2}$ inches before I finished suturing it in position. I then anastomosed the small intestine on the proximal, to that on the distal, side of the invagination, with segmented rubber rings held together by sheepskin strands. Each ring had six rubber segments, to which were attached six linen sutures armed with six sewing needles. Scarification was employed. One over-stitch was employed. A large, unsevered graft of omentum was employed over the invagination and the anastomosis, and sutured into position. The abdominal incision was closed with linen thread, three sutures to the inch, including skin, fascia, muscles, and peritoneum. The dog was slightly ill for three days, after which he was apparently well and happy. He ate and drank naturally.

Autopsy.—The dog was killed on the ninth day.

The abdominal cavity looked perfectly healthy, except the adhesions. Dis-invagination had recently occurred, probably on the eighth day. What was once the neck of the invagination, was a dark contracted ring encircling the gut; what was once the apex was also dark. The intussuscipiens and returning layer of the intussusceptum were quite œdematous. The gangrene was the most advanced in the mucous membrane. An interesting point was observed in that a fæcal fistula started, but was effectually checked by the omental graft and a plug of plastic exudate. The omental graft was mainly glued to points which had been wounded, and not so firmly to smoother gut surface, which shows that scarification should be double, which was not done in this case. The invaginated (excluded) bowel segment, had formed by adhesions two distinct loops, which were each several inches long. The omental attachments were very strong, and the small intestines could be observed to slide to and fro under the arcade thus formed. The adhesions of intestinal loops to points which were abraded, showed the omentum should have been re-spread over the intestines. The anastomosis was perfect. The artificial fistula admitted the end of the little finger, which was much too small for a dog of this size. The sheepskin strands and the rubber tube segments were entirely gone; four linen sutures were yet in the wound. The gut excluded had contracted to 20 inches in length, and decreased in circumfer-

ence. Almost the whole fæcal circulation passed through the artificial fistula. The excluded gut had an entirely different appearance from the other gut. The bile did not color the mucous membrane of the excluded part, but went through the artificial fistula. No fæces were found in the excluded gut. The segmented rubber rings were introduced into the lumen of the intestine through an incision on the gut most distant from the mesenteric attachment. Though the incision was almost an inch long, it contracted to one-half its original size, and possessed a kind of sphincter.

Experiment No. 54.—Bitch, old animal; weight 20 lbs. The creature was chloroformed, the abdomen shaved, and median incision three inches long made. The omentum was pushed to left, small intestine drawn out, invaginated eight inches, and fixed in position with five linen sutures. The gut above and below the invagination was then anastomosed with segmented rubber rings, held together by one strand of raw-hide, and one of sheep-skin. The rings had attached to them six linen sutures, armed with six round sewing needles, and were introduced through an incision on convex surface of the bowel, and the needles pushed from within out. The serous surface lying over the rings were scarified, coapted, and the two lower sutures tied first, then the two end ones, and finally the two upper. An unsevered omental graft was applied over the anastomosis and invagination, and fixed in

position by three linen sutures passed through the mesentery. For three day the dog did well; drank and acted lively; but suddenly became sick, and died on the fourth day. The *autopsy* showed the invagination reduced, but from all appearances, at the end of the third day it had reduced itself so violently that one of the stitches had torn a hole in the gut wall, out of which oozed pus. This fæcal fistula killed the dog. The apex of the invagination presented a gangrenous spot, about the size of a No. 30 sound. The tissues and returning layer of the intussusceptum were swollen, œdematous, congested, and of a dark-blue color. The omental graft had formed adhesions over most of the parts, but immediately over the fæcal fistula it showed intense redness, and congestion with mottling. Much care and practice must be exercised in suturing an invagination in position, as the profound shock given to the gut-wall and peritoneum quickly induces intense pathological changes, especially in nutrition, circulation, and nerve supply. The stitches at first may not have passed deeper than the aponeurosis of the gut-wall, but weakened tissue easily allows rapid ulceration through the remaining part, and fæcal fistula results.

Invaginations reduce themselves very irregularly —slowly and gently, and rapidly and violently. This case showed a sudden reduction on the fourth day, with such destruction of physiological functions as to

exclude any process of repair, and the fistula remained open. If the tissues were healthy, the fistula would be plugged with an exudate as fast as it was formed. Scarcely any adhesions existed, only a slight exudate bathed the invaginated parts. The neck was still highly constricted. The anastomosis was well established. All fæcal circulation passed through the artificial fistula. The peritoneal graft was quite well adhered to the anostomosed parts. The rings were well in position, and the raw-hide and sheep-skin strands well advanced toward dissolution.

Experiment No. 53. — Bitch; weight 20 lbs. This animal had been operated on for circular enterorrhaphy, and ten days after for ileo-ileostomy, and twenty-three days from the first operation was a third time operated on for the purpose of producing an artificial invagination. She was much emaciated by marasmus, though she ate well, and had lost about seven pounds by the first two operations. The belly being opened, the omentum was pushed to left, a piece of small intestine drawn out, the loop invaginated six inches, and held in position by four sutures. The animal rallied well. In ten hours she became drowsy, and died comatose twenty hours later. The *autopsy* showed fatality supervened from gangrene of the intussusceptum (and shock); the neck showed about one and one-half to two inches more. The apex was swollen into a large knob, and the convex surface of the return-

ing layer of the intussusceptum was very œdematous There was about two ounces of serum held in the invagination. The mesentery was not very much congested. The middle layer of the intussusception is the one which shows almost all the pathological changes due to the returned flow of venous blood being cut off at both ends—the apex and neck. No adhesions and no plastic exudate existed. The reduction was so difficult that it disturbed the integrity of the gut tissue. The resistance was caused by the knob at the apex, and the swollen, curved intussusception. The entering layer of the invagination was much compressed and pale.

Experiment No. 74.—Bitch; weight, 20 lbs; was chloroformed and shot while lying down. One hole was found in gut, and closed with Lembert stitch. I then invaginated the intestine seven inches, and sutured it in position with one stitch passed through the mass of mesentery at the neck of the intussusception. It contracted to an invagination of five inches in 45 minutes. I then anastomosed the gut on the proximal and distal sides of the intussusception with rawhide plates. The plates were a little too large, and left a dangerous point on one side. An unsevered omental graft was applied over the anastomosed parts, and fixed in position by several stitches passed through the mesentery. The excluded gut containing the invagination was 20 inches long.

She succumbed six days after the operation from a fæcal fistula which occurred at one side of the plates. She did fairly well for five days, when she was suddenly taken very sick, and died in 24 hours. The fistula no doubt broke on the fifth day. The rawhide plates were entirely absorbed; a few stitches remained in wound; fæcal circulation took place entirely through the artificial fistula, as not a trace could be found in the excluded gut. The invagination had retained about three inches of the original seven. The apex was gangrenous, and had sloughed out a perforation sufficient to admit the tip of the little finger. The entering layer of the intussusceptum was fresh, pale, and compressed to the size of a lead-pencil. The returning layer seems to suffer about 90 per cent. of the pathology. The intussusception was easy to dis-invaginate. Considerable adhesions existed between the layers of the intussusceptum. The apex presented a swollen knob, and the convex-curved border of the intussusceptum was quite œdematous. The anastomosis had relieved the invagination of the pressure which appears to be the main point of danger, and which also gives the main periodic pain. It seems that if the pressure of the fæcal circulation can be turned into another channel, the essential point of danger, and the pain, is removed from cases of obstruction and invagination. This is easily accomplished by anastomosing the gut above to that below the obstruction, or by invagination with

segmented rubber plates. The neck of the invagination was only slightly gangrenous. Blood was oozing out of the apex, which felt and looked much like an os uteri.

Experiment No. 56.—Dog, puppy; weight, 20 lbs. The abdomen was opened, a loop of colon drawn out, invaginated 8 inches, and fixed in position by 4 linen sutures. The gut was then anastomosed on the distal and proximal side of the invagination with segmented rubber rings held together with sheepskin strands. The dog died 2 days after operation, from fæcal fistula caused by the invagination sutures tearing a hole in the gut wall as it dis-invaginated itself. The intussusceptum was swollen, œdematous, and deeply congested, of a dark, dusky red, bordering on gangrene. I think disinvagination occurred at the end of the first day. The anastomosis was healing nicely, and had formed strong adhesions. The omental graft had grown quite firmly around the anastomosed parts. The peritonitis was purely local, being limited to points of fistulæ.—Invagination gives great shock to animals.

Experiment No. 57.—Dog; weight, 20 lbs. The abdomen was opened, a loop of intestine drawn out, invaginated 4 inches, and fixed in position by 4 sutures. This animal was sick only about 12 hours, after which he ate, drank, and played. The dog was afterwards chloroformed for another operation, and died under anæsthesia. The invagina-

tion had reduced itself, showing no pathology. It broke away 2 sutures of fixation, and had reduced itself with 2 sutures still in position, giving the intestine sharply kinked loops, which did not seem to disturb fæcal circulation.

Experiment No. 49.—Dog; weight, 20 lbs. A loop of small intestine was drawn out of an incision (median), and invaginated 4 inches. It was fixed in position by 5 continuous sutures passed through serous nnd muscular coats. The dog's abdomen was reopened toward the close of the third day. The dis-invagination had occurred by breaking away the stitches; it had occurred only quite recently, as the proximal gut and invagination were dark blue and very œdematous. Severe infection had taken place, and second operation was done, excluding the invaginated gut by anastomosing it above and below with segmented rubber rings, but the dog died 20 hours after from peritonitis and shock. The autopsy showed that the anastomosis was nicely healing, and had become quite firm in 20 hours. I am fully convinced that the methods of anastomosis are amply sufficient to save life in cases of intestinal obstruction and invagination. It should be remembered that many of the dogs had a double operation; that the first produced often no fatally severe effects, and the animal resisted infection; but it was the second operation that profoundly affected the animal, and generally the one from which it died. The cause of death

was in most cases overwhelming infection, or shock. Among the whole series of dogs, which at this writing are about 175, I never dressed one. The abdominal stitches were seldom removed, and all the dogs were kept in a barn.

Experiment No. 46.— Bitch; weight, 20 lbs. A loop of small intestine was drawn through a two-inch median incision, invaginated four inches, and fixed in position by four linen threads at the neck. Abdomen was reopened 48 hours after, and the invagination found reduced to two inches in length. No fixation sutures had torn out. The animal's peritoneum was severely infected from some cause. The invagination was difficult to find. The intestine at the proximal and distal sides of the intussusception was anastomosed by segmented rubber rings held together with strands of rawhide; an unsevered omental graft was applied over the anastomosed parts. The difficulty of diagnosis in this case was instructive. Two physicians made the intra-abdominal examination with the whole hand and gave it up. Exventration was then produced, and the gut run through the hand and before the eye; it was observed that it induced very profound shock. The gut was returned to the abdominal cavity as soon as it was drawn out. I think it a good plan to carefully withdraw the gut, and only seize it between the finger and thumb every six to eight inches, or to manipulate as little as possible.

She died at the end of the third day. The remaining part of the invagination had reduced itself, and made a fæcal fistula by tearing out the sutures of fixation. This was no doubt the original source of the infection, but it could not be domonstrated at the second operation. I found, by suturing the fixation threads more into the mesentery, that they did less damage and held the invagination more securely in position. No gangrene existed.

Experiment No. 43.—Dog; weight, 40 lbs. Through a median incision three inches long, a loop of small intestine was drawn and invaginated four inches; then returned and abdomen closed. After 48 hours abdomen reopened. The invaginated spot could not be found by intra-abdominal examination. It was found by exventration and passing the gut through the fingers and before the eye. A knuckle of gut was given to an assistant to locate a starting point. The operator would then go to the end one way and then return to the starting point and go the other way; all this was required to find the invagination. It had dis-invaginated itself very forcibly. Two stitches had torn away and the gut had released itself by wiggling out between the other two. It had so twisted that it even narrowed the gut lumen considerably. The dis-invaginated gut was swollen, patulous and œdematous. The gut above and below the location of the invagination was anastomosed with raw-hide plates, and an unsevered graft applied over the whole. The dog

was infected from some cause, and local peritonitis existed.

The dog died nine days after the first operation from peritonitis. The *autopsy* demonstrated the intestines bathed in a sero-purulent fluid. The plates were entirely absorbed, and the anastomosis perfectly established. The artificial, bi-mucous fistula was large enough to easily admit the thumb, and so far as could be determined, all fæcal circulation was passing through it. The excluded gut was contracted, and the reduced invagination still retained two sutures of fixation, between which dis-invagination had occurred. The gut had so twisted itself between these stitches as to narrow the lumen one-third of its original diameter; it kinked the gut so that a solid adhesion was formed. The peritoneal graft had formed firm and solid adhesions. The peritoneum showed the most wondrous appearance. Thousands of fine tortuous arteries and vessels were seen like crimson twisted silk, meandering over the mottled fields of the peritoneum, which under the microscope appeared like tissue injected red. It was the most remarkable sight I ever beheld, to see the thickly laid blood vessels like crimson gold, wandering in corkscrew fashion over the peritoneal ground. The cause of death was the simple lack of antiseptic surgery. The means of anastomosis proved amply sufficient. Better surroundings would have saved the dog.

Experiment No. 38. — Dog; weight, 40 lbs.

Through a median incision two inches long, a loop of colon was drawn, invaginated 3½ inches, and sutured in position by three linen threads passed through serous and muscular coats of gut wall. Fifty-six hours after, the dog's abdomen was reopened. The dog was infected, as local peritonitis existed. The invagination had reduced itself by tearing out the 3 fixation sutures. The ilium and colon were anastomosed, excluding the location of invagination, with segmented rubber rings held together with 4 strands of raw-hide. A peritoneal graft was applied, and held in position by 4 sutures. As peritonitis existed, I attempted to lessen it by pouring hot water into the abdominal cavity; the water was as hot as I could bear the hand in. Some 3½ quarts apparently thoroughly aroused the dog from all shock, and seemed to put new vigor and life in him. He died on the third day, however, from intestino-peritoneal septicæmia; death was caused from perforations resulting from the fixation sutures. The anastomosis was healing nicely, and fæcal circulation passing through the fæcal fistula. The peritoneal graft had grown quite firm. The rings were *in situ*. The perforations had become large, and thus overwhelmed the system with poison. It should be observed that most of the dogs died from infection (which could be avoided by better hospital surroundings), or fæcal fistula arising from the fixation sutures, which would not militate in any other cases.

Experiment No. 59.—Dog; weight 20 lbs. Abdomen was shaved, a loop of small intestine drawn through a free median incision, and invaginated six inches. The gut above and below the invagination was next anastomosed with segmented rubber rings, held together by sheep-skin strands; omental graft applied. Dog died at end of fourth day from intestino-peritoneal septicæmia, caused by two perforations resulting from the fixation sutures of the invagination.

The invagination had released itself, but not until gangrene had occurred. The apex was gangrenous, and the neck had begun to undergo same process. The rubber rings were well in position, and the anastomosis healing nicely. The sheep-skin strands had given away at one point on one ring. The intense local peritonitis was variagated in color, and mottled. This intestino-peritoneal septicæmia, originally suggested by Dr. Vecheré, is a very distinct disease in clinical manifestation, and pathological appearances. It will kill a dog, sometimes in a day. It is likely some microbe, the explosive increase of which in the peritoneal cavity, is accompanied by the product of toxic substances, or ptomaines, whose absorption causes the rapid, fatal poisoning. I have yet to see the disease in any dog which had no intestinal perforation. If the omental graft had been sutured more firmly, and coapted more closely, it might have saved the dog.

RESUMÉ.

Of the eleven cases, Nos. 49, 56, 74, 54, 53, 54, 57, and 59 suffered from more or less gangrene (63 per cent.), while no gangrene was found in Nos. 43, 38, 46, and 51 (36 per cent.). Dis-invagination occurred in Nos. 49, 54, 56, 57, 59, 43, 38, 46, and 51, notwithstanding the invagination was sutured with from two to six stitches (89 per cent.), while Nos. 74 and 53 did not dis-invaginate, but both were gangrenous (11 per cent.). Several of those which did dis-invaginate required from a few minutes to seven days. Death from fæcal fistula arising from the tearing out of the sutures of fixation of the invagination occurred in Nos. 59, 38, 46, 49, 56, and 54. Death occurred in No. 74 from fæcal fistula arising on the fifth day at the side of the absorbed rawhide plate, and in No. 51 from chloroform. Death occurred in No. 53 from gangrene and shock. No. 43 died from diffuse nine-day peritonitis. No. 57 was killed. Nos. 43, 49, 53, 38, and 43 had double operations. The anastomosis seemed to establish itself almost every time.

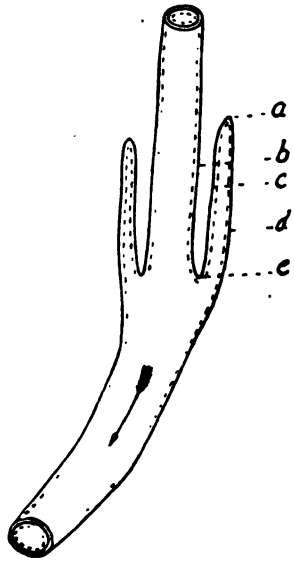
The means at our hands are amply sufficient to establish new channels of fæcal circulation by lateral anastomosis through rawhide plates and segmented rubber plates. Establishing a new fæcal channel relieves the invagination of dangerous pressure, and quiets its peristaltic action. It may be remembered that many more of the dogs would have lived if we had not per-

formed a second operation on them, and thus infected and shocked a second time. Practical experience, as well as medical history, demonstrates invagination to be the saddest chapter and most destructive accident in all the field of intestinal surgery. More victims succumb to it, and pass to the "low green tents whose curtains never swing outward," than from any other form of bowel obstruction. It may be here stated that the object of these clinical experiments was not to acquire statistics or a high per cent. of recoveries, but for the purpose of an inquiry and investigation into a special field of intestinal surgery, and to study the clinical manifestations and pathological conditions of wounds and repair of the alimentary canal. So far as I have been able to observe, a truthful report has been presented. There are, however, problems yet to be solved, and processes yet to be tested, which time and research only can bring forth by experimentation.

A few fundamental principles, and some of the most salient features of invagination will be considered in this chapter for the benefit and interest of those readers who have neither time or opportunity to experiment, nor extensive library to consult.

A reference to the cut on page 147 will serve better to demonstrate the pathological anatomy than any description. This represents an invagination in vertical section. It may be observed that there are three layers of gut wall on each side, and that

mucous membrane lies against mucous membrane, and peritoneum against peritoneum. The outer layer is called the sheath, receiving layer or *intussusscipiens* (*d*). The most inside layer of the three is the



a, Neck of invagination.
b, Entering layer of intussusceptum.
c, Returning layer of intussusceptum.
d, The sheath or intussuscipiens.
e, Apex of invagination.
b+*c*, Intussusceptum.

entering (*b*) layer, and the middle one (*c*) is known as

the *returning* (*c*) layer. The returning and entering layers are together known as the *intussusceptum.* The neck (*a*) is at the junction of the returning (or middle) layer, and the intussuscipiens. The apex (*e*) is at the end of the intussusceptum where the entering and returning layers meet.

An invagination may occur at any part of the bowel from the duodenum to rectum. The enteric variety constitutes about 30 per cent., the ileo-colic 50 per cent., and the colic 20 per cent. of all invaginations. Invagination constitutes one-third of all intestinal obstruction, is more common in males than females, and is essentially a disease of childhood. One-quarter of invaginations occur before the end of the first year of age, and one-half before the tenth year of life. The acute forms are more liable to occur in childhood, while the chronic forms take place in active adult life. In the artificial production of invagination, it is at once seen that the invagination grows at the expense of the sheath or intussuscipiens. For example, in the ilio-colic variety, the ileo-colic valve will form the apex, no matter how much gut is invaginated. The ascending, transverse, and descending colon may successively become invested, but the valve of Bauhin will still form the apex even if it present at the anus. Again, suppose the jejunum invaginate itself in the ilium, the jejunum will form no more of the active growth of the invagination, even if it reach the ileo-colic valve, but the invagination will

grow at the expense of the ilium, *i. e.*, the intussuscipiens. The ileo-colic variety differs from this by growing at the expense of the entering layer of the intussusceptum. It consists of a prolapse of the lower end of the ilium into the colon through the ileo-colic valve. But the valve remains stationary, while the continually changing apex formed by the successive parts of the ilium moves on toward the anus. Invaginations may be divided into two classes. The first is called the "invagination of death;" it is non-surgical, and may be observed by chloroforming a dog to death, and during the process opening the abdomen; many times the intestines can be observed in a tumultuous, disordered, vermicular action,—if they are quiet, some irritant, such as cold air, friction, etc., will soon induce it. The invaginations of death are non-pathological; they show no congestion, inflammation, or gangrene. They are often multiple, and ascending or retrograde. They are especially apt to occur in patients who die of some brain disease which affects the origin of the pneumogastric nerve, and sympathetic ganglia. These nerves preside mainly over the alimentary canal.

The second class, termed the obstructive or inflammatory invagination, alone concerns the surgeon. It presents pathology in its congestion, inflammation and gangrene.

This class is almost invariably descending and single, but extreme varieties are recorded as being multiple and ascending, or retrograde.

THE PATHOLOGY OF ACUTE INVAGINATION.

The pathological conditions of acute invagination are: (*a*) Partial or complete obstruction of the intestinal lumen: (*b*) Strangulation of some part of the invagination, and: (*c*) Gangrene.

Strangulation and gangrene may be both absent in the chronic form. Relative to obstruction, I found in a larger number of experiments than is recorded in this chapter, that where I produced artificial invagination, the autopsy demonstrated that complete obstruction was not once found; gut above the invagination was very little if any changed; few symptoms of obstruction were presented. In some autopsies the entering layer was only as large as a No. 14 sound and would permit the entrance into the lumen of the gut of a No. 10 sound. Such an opening was very small but permitted sufficient fluid to trickle through to allow of the performance of necessary functions.

The most concise method, in this short sketch of the pathology, will be to note the conditions and changes of each essential part concerned in the invagination. The most prominent gross feature which strikes the eye in an invagination is the *mesentery*. As the invagination grows, the mesentery is drawn into the space between the layers of the intussusceptum. It is then in the shape of a cone with its apex at the apex of the invagination and its base at the neck of

the invagination. As the invagination grows the traction on the mesentery generally increases. It must be remembered that the dragging on the mesentery is not in proportion to the size or length of the invagination. In the intussusceptions which I make on dogs the invagination acquired immediately a curved outline. The invaginated bowel represented the circumference of a circle, and the mesentery represented the radius with the vertebral column as a center, so that the mesentery does not become elongated so much as would appear to permit a lengthy invagination to occur. I found that the mesentery was the object that checked the growth of the invagination, and it did it mainly because of the difficulty of a large roll or bulk of mesentery collecting at the neck of the invagination. It was also clearly seen, when we made long invaginations, that the axis of the intussusceptum and of the intussuscipiens both had curved outlines, but their axes were not parallel to each other on account of the greater traction of the mesentery on the intussusceptum, which was so strong at times as to give the axes of the intussusceptum a slit-like form. This slit or mouth at the apex of the intussusceptum would turn its lumen toward the mesenterial border of the intussusscipiens, and might in this manner obstruct the bowel. The condition of the mesentery in the invagination varies considerably; it is generally more curved in the small intestine and straighter in the large bowel. In cases of extensive invagination, the

curve-shaped mesentery lies tightly compressed between the two layers of the intussusceptum. It is so compressed that arterial blood will pass through the thick-walled arteries by the force of the heart. But the venous blood cannot return through this tightly compressed tissue, because of the collapse of the thin-walled veins and lack of propelling force. Hence, congestion, exudation, and gangrene, take place, just beyond the mesentery, in the apex and convex border of the intussussceptum.

It is simply a physiological law, that blood, serum, and fluids, will accumulate in the points of least resistance. My observations are, that the mesentery becomes gangrenous, generally, the latest, and that the mucous membrane of the bowel succumbs first. The obstruction to the returned venous blood causes such engorgement that hæmorrhage takes place from the mucous surfaces, especially the apex.

Simply invaginating the bowel leads of necessity neither to strangulation, nor complete obstruction. Strangulation, or gangrene, arise from the arrest of the returning venous blood. Invagination may lead on to grangrene, and death, or recover by spontaneous elimination of the gangrenous gut, or it may become chronic, and kill the patient by long-continued repeated attacks of pain.

I knew one to wear a patient to death in fifteen months. It is reported that a patient lived eleven years with one. The complete obstruction may occur in different ways:

(*a.*) The slit-like orifice of the intussusceptum may be dragged against the wall of the intussuscipiens by the tensionized mesentery:

(*b.*) Congestion, inflammation, and exudation, may so thicken the parts of the invagination as to narrow the bowel lumen. In some I made an dogs, a No. 10 sound would fit tightly:

(*c.*) The intussusceptum may be kinked, or bent, so as to narrow the gut-passage:

(*e.*) The narrow passage may be blocked by some mechanical accident, *e. g.*, undigested food, enteroliths, etc.

The reducibility of invaginations is an important subject which I studied in the experiments. Some invaginations became so irreducible in a few hours that the gut would tear in dis-invaginating them, while some would dis-invaginate themselves in spite of fixation sutures, in from 10 hours to 7 days. If the invagination is irreducible, cure must result by spontaneous elimination by gangrene, or anastomosing the distal and proximal extremities of the gut with segmented rubber rings. With or without resection, even if recovery take place by sloughing, it is stated that 40 per cent. die afterwards from stricture and other causes. It might be thought that peritonitis (local) and exudates would play a large rôle in making invaginations irreducible, as the books state that adhesions are found in 80 per cent. of chronic, and in 40 per cent. of acute, invaginations. But the experiments

on dogs demonstrated to me the adhesions had but a small part in rendering invaginations irreducible. It depended rather on other causes, which I will mention, and add some suggested by others:

The most prominent one in an early invagination is the swollen knob at the apex, and the swollen curved border of the intussusceptum. I have seen this very marked. The swelling will generally produce a curve in the invagination, and so make reduction difficult. The invagination may be twisted on itself and thus rendered irreducible. In ileo-colic invaginations the valve of Bauhin may constrict the ilium so as to engorge it, and thus render reduction hopeless; a polyp on the apex enhances irreducibility. The gut above the invagination changes but little. It sometimes thickens. The main changes in the intussuscipiens is thickening and gangrene. The intussusceptum receives the main injury, and suffers the main pathology. The stages are congestion, inflammation, exudation, and gangrene. The intussusceptum becomes so engorged that the blood flows from the mucous membrane, and it is thought blood appears in the stool in 80 per cent. of cases; blood could be seen from apex to neck in some antopsies on dogs. Gangrene, which is an important matter in this part, nearly always attacks the returning layer first. The gangrene may involve the whole intussusceptum, so that it will separate at the neck, and be discharged per rectum. Such gangrenous gut may come away in

shreds or pieces of varied size. Cruveilhier reports a case where over nine feet of gut was sloughed away and passed per rectum. The dangerous point of separation is high up in the neck, where perforation may occur. I have seen the apex slough away in dogs in less than a week, so that the little finger would enter the slough. Acute invaginations are apt to suffer from gangrene at the neck, while chronic cases suffer oftener at the apex. It is asserted that epithelioma is not an infrequent accompaniment and instigator of invagination; however, epithelioma might grow as the result of the invagination.

THE ÆTIOLOGY OF INVAGINATION.

Much discussion has arisen as to the cause of invagination, but the best view is, that it is due to disordered, irregular action of the muscle in the gut wall. There is a rare form called the invaginatio-paralytica, and a common form called the invaginatio-spasmodica. The clinical proof that invagination is due to irregular peristalsis mainly rests on the classical experiments of the celebrated Prof. Nothnagle, of Vienna, who demonstrated on animals, by the aid of electricity on normal intestines, and on intestines with segments paralyzed, that both kinds of invaginations could be produced by causing irregular muscular action in the gut-wall. The circular and longitudinal fibers both play a rôle, and the affair should not be considered so much as a propulsion of

one piece of gut into another, as a matter of one segment of gut being drawn over another.

Quite a number of experiments have demonstrated to me that, invagination is more common than is generally recognized, and that they dis-invaginate.

It appears to me that many severe forms of colic can be more reasonably explained by the view that they are temporary invaginations. This sounds more reasonable when it is observed that children and delicate persons are the ones who especially suffer from colic, and those are the very persons who suffer from invagination.

Invaginations have a clear, distinct connection, and relation to the central nervous system, particularly the route of the pneumogastric nerve, and the sympathetic system. Many authors have warmly discussed the reasons of so frequent ileo-colic invaginations, hence the following is offered: Man may be considered to have three ani, and at the same time three weak points – at the duodenum, cœcum and anus. The duodenal valve and the ileo-cœcal valve may be called physiological ani, while the end of the rectum may be called a mechanical anus. These three ani have three distinct sphincters. Now prolapse can occur at the valve of Bauhin in the same manner as it can at the anus. The analogy holds good in all conditions of life. As this is important, covering 50 per cent. of invaginations, I will quote Dr. Leichtenstein from Ziemssen's Encyclopædia, page 617:

If we consider that the ileo-cœcal opening is distinguished by a sphincter, the contraction of which can increase to powerful tenesmus, we recognize there is a complete analogy between the conditions of complete invaginations in the regions of the cœcum and the different kinds of prolapse of the rectum, which, like ileo-colic invaginations is found most frequently in early childhood.

Just as anal tenesmus excited by catarrh or abnormal irritability of the terminal portion of the ilium, is of great importance in the production of many ileo-cœcal and ileo-colic invaginations, so in many cases we see invaginations in the region of the cœcum follow prolonged diarrhœa or colic, the taking of unsuitable foods, or, especially in early infancy the withdrawal of the mother's milk and in the substitution of improper food, and here cœcal tenesmus plays an important part. If the cœcum or colon are rendered easily movable by their mesentery — as is regularly the case during early life—the repeated and more forcible peristaltic pressure towards the persistently contracted ileo-cœcal sphincter causes ileo-cœcal invagination. If the cœcum is firmly fastened down so that it cannot be turned in and invaginated into the colon, prolapse of the ilium into the colon takes place, with formation of an ileo-colic invagination, just as prolapse of the rectum may follow violent anal tenesmus. If neither of these happens, invagination of the lowest part of the ilium may occur, as is the case also in the rectum when it becomes invaginated in itself above the obstinately contracted (tenesmus) sphincter, and is finally prolapsed (called by surgeons "prolapse of the rectal wall with invagination"). If ileo-cœcal invaginations are very common in children, and ilium invaginations, on the contrary,

very rare, the reason lies in the greater mobility in the cœcum and ascending colon, allowed by the mesentery, and the consequent removal of an obstacle to invagination. In adults, this element is removed, and we find ilium invaginations as frequent as ileo-cœcal.

In the ætiology of invaginations, about 60 per cent. of cases arise without any known cause. Dysentery may be mentioned as a cause. I saw at an autopsy, some 12 inches of decending colon invaginated toward the rectum; the young man was suffering from dysentery just before he died, and the diagnosis was not made until section occurred. Most authors mention diarrhœa, enteritis, typhoid fever ingesta, polypi, injuries, cold, and the eruptive fevers, as causes of invagination.

Peritonitis favors it also by paralyzing segments of bowel, and thus causing irregular peristalsis.

THE SYMPTOMS OF INVAGINATION.

Most authors follow Dr. Rafinesque in his classification by noting: (*a*) Ultra-acute cases which die within 24 hours: (*b*) Acute cases lasting between two and seven days: (*c*) Subacute cases whose duration may be between seven and thirty days, and: (*d*) Chronic cases when they last beyond a month. Age, sex, and frequency were previously noted. Previous history is generally of little value, yet one could surmise from oft-repeated attacks of colic which appear to me to be temporary invaginations. The attacks generally

arose suddenly. I saw a case in which it arose suddenly while at work; he was at the time suffering from colic due to indigestible food, and had almost constant tenesmus. I knew of another case with such violent, sudden pain that the man rolled on the ground with distressing cries of intense agony, dying in some eight days. *Pain* is one of the most conspicuous features in acute cases; dogs generally have considerable severe periodic pain up to the point of dis-invagination or gangrene. In gangrene, the pain generally subsided and death followed. The difficulty of producing artificial ileo-colic invagination on dogs did not give so good an opportunity to study its features as was desired; we sometimes ruptured the gut in executing it. One positive feature about this matter is, that pain in invagination was not constant in dogs. It was rather periodic, paroxysmal, and intermittent; but as the disease advanced, the pain became more constant, until gangrene or dis-invagination resulted. (I dealt with no chronic or over thirty day case in the experiments). By disturbing the dog, an attack of pain could be brought on which would last a few minutes. Some dogs would quickly get over the attack, and wag their tails and act free from pain and happy, while others slowly recovered, and then seemed to suffer shock and to be ill most of the time. I did not observe regular periodicity nor any fixed time for an attack of pain, but movement almost always

brought it on. I think the dogs which had invaginations involving the small intestine were more ill than those having invagination of the larger bowel. But the condition and state of the invagination told the whole story, as was invariably demonstrated at the autopsy. The activity which occurred at the seat of invagination, was the standard of measure of the degree, and intensity of the disease in general. The pain varied very much, as was shown by the various postures assumed by the animals, but in general it was severe.

Vomiting was not conspicuous in any one dog. It was very variable, and seldom arose unless the animal took some food, or was suddenly stirred up; if he drank much cold water, he would generally vomit. However, it must be remembered that dogs do not manifest such severe vomiting as man, in bowel obstruction at least. I often observed this as a fact, so far as I could judge. Also, I have seen several invaginations in the human, but among none as a prominent feature, because the bowel is not completely obstructed. In all the vomiting I saw in dogs with invagination, it was preceded and accompanied with pain, or, so far as I could judge, peristaltic action of the alimentary canal. Diarrhœa, bloody and mucous, was the general condition which existed in invagination.

Tenesmus was severe, quite early, in about one-third of the cases.

Tension of abdominal wall, and meteorism, are not met with to any great extent in invagination. Considerable attention was paid to the ability to find the tumor of the invagination, and its recognition was found very uncertain. At times we were unable to find the tumor by intra-abdominal examination, and wholly unable, in a large majority of cases, to find it by palpation with deep narcosis. After repeated trials, I cannot agree with authors who say it can be recognized in more than 50 per cent. of cases under an anæsthetic. Of course, it would be more likely to be recognized in the ileo-cœcal variety, with which we did the least work. It is said one-third of this variety reach the rectum, and hence are within reach of the hand. The dog autopsies showed that the tumors varied much in size and shape, depending much on position and pathology. The position in the small intestine will be near the mesenteric attachment, and in the large intestine, generally along the tract of the colon. The abdomen should be examined from day to day, and also while under an attack of pain. The tumors which reach the rectum travel quite fast; some will reach the rectum in acute cases from one to seven days, and in chronic cases in some fifteen days. These rectal tumors have been mistaken for other conditions, and the part amputated, some with recoveries, but generally death. Space forbids a discussion of chronic invagination.

THE PROGNOSIS OF INVAGINATION.

It may be stated that the general mortality of known cases of invaginations is 75 per cent. This is rather the mortality of recorded cases. It is a disease of childhood, with a mortality of over 80 per cent. Without operation, the only method of cure is spontaneous elimination of the bowel, which is said to occur in over 40 per cent. Again, it is asserted that of those who have been subjects of spontaneous elimination of the bowel, 40 per cent. die, so that the ultimate recovery is small. The elimination is influenced by the position of the bowel, being greatest in the small intestine. Statistics by Treves give the percentage of eliminations in the different parts of the canal, as in—

Ileo-colic	invaginations.....	20	per cent.
-cœcal	"	28	" "
Enteric	"	61	" "

Spontaneous elmination of gangrenous gut increases with age. Leichtenstein states that in the first year of age it is only 2 per cent., at 5 years it is 6 per cent., at 10 years it is 38 per cent., and at 40 years it is 40 per cent. The gangrenous gut sloughs away in from 3 days to 6 months, or longer. I have seen gangrene in a human, with femoral hernia, begin to slough in about 12 hours, and the neck of an invagination in a dog in about 10 hours. I saw one dog in which the gangrene began to slough at the apex of

the invagination on the fourth day. The cause of death in spontaneous elimination is, generally, perforation at the point of separation. The sloughed gut may block the passage, or cicatrices follow which may result in stricture. Ulceration may still continue at point of separation. Hæmorrhage or septicæmia may, either one, kill the patient. In cases of invagination below the ileo-cœcal valve, insufflation of air or hydrogen gas, and injections of water, should be carefully tried in order to induce dis-invagination. When the invagination is situated above the valve of Bauhin, I am fully convinced from numerous experiments on the cadaver, and on dogs, that fluids should not be used, as rupture of the serous covering of the bowel will often occur before fluid will pass the ileo-colic valve. Hence with invaginations situated above the ileo-cœcal valve, only air or gas should be insufflated. The insufflation should be done slowly and steadily, and auscultation of the canal, and especially the ileo-cœcal valve will inform one where the gas stops and the obstruction lies. This is not always capable of diagnosis. Occasionally on removing the invaginated parts from the abdominal cavity, the dis-invagination is best accomplished by forcibly pressing out the œdema by squeezing it between the two hands.

CHAPTER XIII.

VOLVULUS.

Volvulus, or twisting of the bowel around its mesenteric axis, constitutes one-twentieth of all intestinal obstruction. The vulnerable weak points of man's alimentary canal, again suffer the brunt of the burden. Sixty per cent. of volvulus occur at the sigmoid flexure, thirty per cent. at the cœcum, and ten per cent. in the small intestine. The whole of the ætiology of volvulus is not yet solved, still the main causes are a long or elongated mesentery, quite free from fat. Protracted constipation plays a rôle, and age is a factor. In the experiments on animals I did not succeed in causing obstruction of the bowel by making artificial volvulus. I have twisted the bowel four times around its mesenteric axis, and then held it in position by fixation sutures, but even that did not obstruct the bowel. The gut and mesentery at first became considerably engorged and hyperæmic, but became relieved as time went on, without much disturbance to the animal. Any one can observe and demonstrate on a cadaver that mere twisting does not cause the occlusion of the bowel. I demonstrated this on living dogs. I have examined, post-mortem, bodies with long mesenteries, where if one will push the fæces into the sigmoid flexure, and then allow the weighted sigmoid to drag on its twisted

axis, it will quickly be seen to constrict the lumen of the bowel. Attempts now to force bowel contents through the volvulus will fail; it is strangulated, or rather the intestine obstructed, not from the mere twist, but from a tightening of the twist by a weight. There is also a peculiar spiral force in some, which, like invagination, continually acts in a pathological direction. Sometimes a volvulus will spring back as quick as it is reduced. Volvulus is occasionally very rapidly destructive and fatal. It may kill in one day, and its average length is four days. Statistics show it to be three times as frequent in men as in women. Once a volvulus has occurred it (probably) will never reduce itself, and the only way to save the patient is to perform laparotomy. Meteorism is generally present.

Experiment No. 58.—Dog, male; weight, 30 lbs. Abdomen, shaved and opened, a loop of small intestine drawn out, twisted around its mesenterial axis four times, and firmly stitched into position by fine sutures. Dog killed about two weeks after. The volvulus was reduced; but in reducing itself, two bands were made which simply wound around the gut as it unfolded itself. They were omental bands; one about as long as a man's little finger, about one-half as thick, and hugging a small intestine. The other omental band was six inches long, about as thick as a pipe stem, and stretched itself around a bowel. These bands were simply made as the volvulus un-

rolled itself. Though at first considerable venous engorgement took place, yet no obstruction occurred. The dog was not sick at any time.

The treatment of volvulus is early laparotomy. The abdomen should be opened in the median line, and the hand first sent to find the cœcum, and second to find the sigmoid flexure, as 90 per cent. of volvulus occur as these two points. If the volvulus can not be untwisted and is not gangrenous, anastomose the gut above to the gut below with segmented rubber plates. It can be done in fifteen minutes. If gangrene has occurred, the gangrenous portion should be resected, the two bowel ends invaginated, and closed with a few continued sutures. The proximal and distal bowel ends should then be anastomosed with the rubber plates.

The distended coils of intestines which obstruct operative work should be incised, and a long rubber tube introduced which will conduct out the gas, when the coils will collapse. If the mesentery is very much elongated, a reef or tuck can be made in it, and fixed in position to prevent recurrence.

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